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VOLUME TWO

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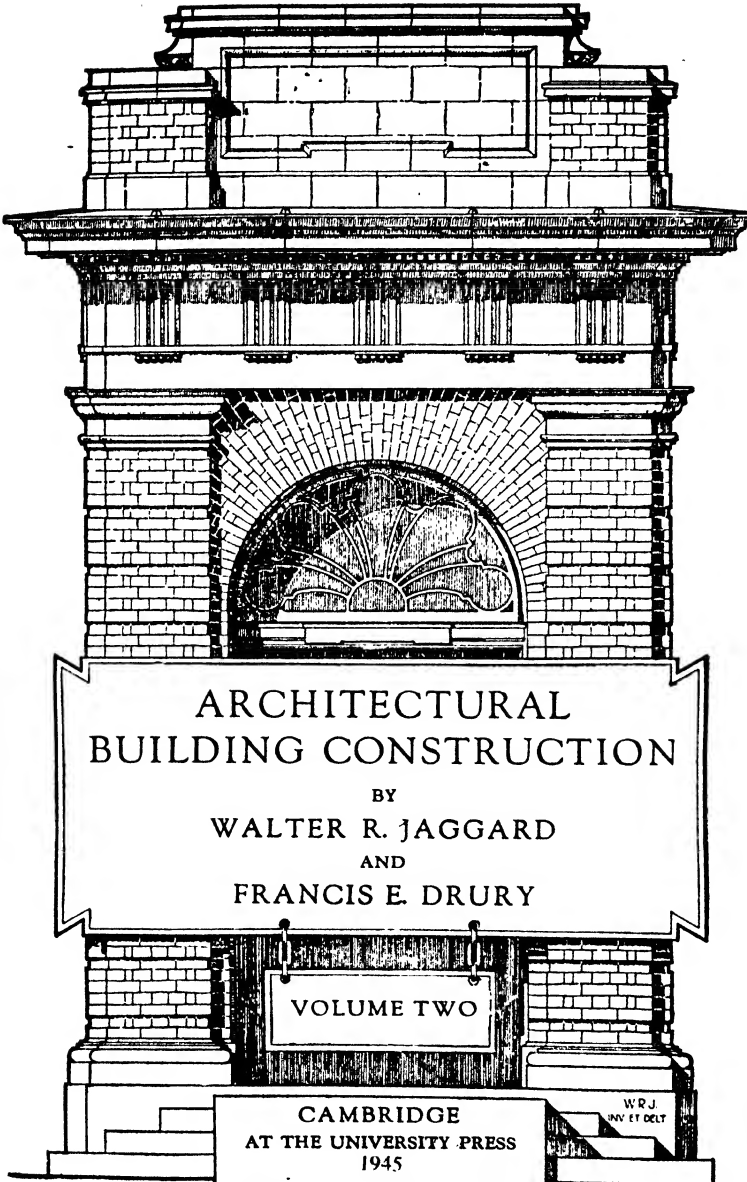

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BY

WALTER R. JAGGARD

AND

FRANCIS E. DRURY

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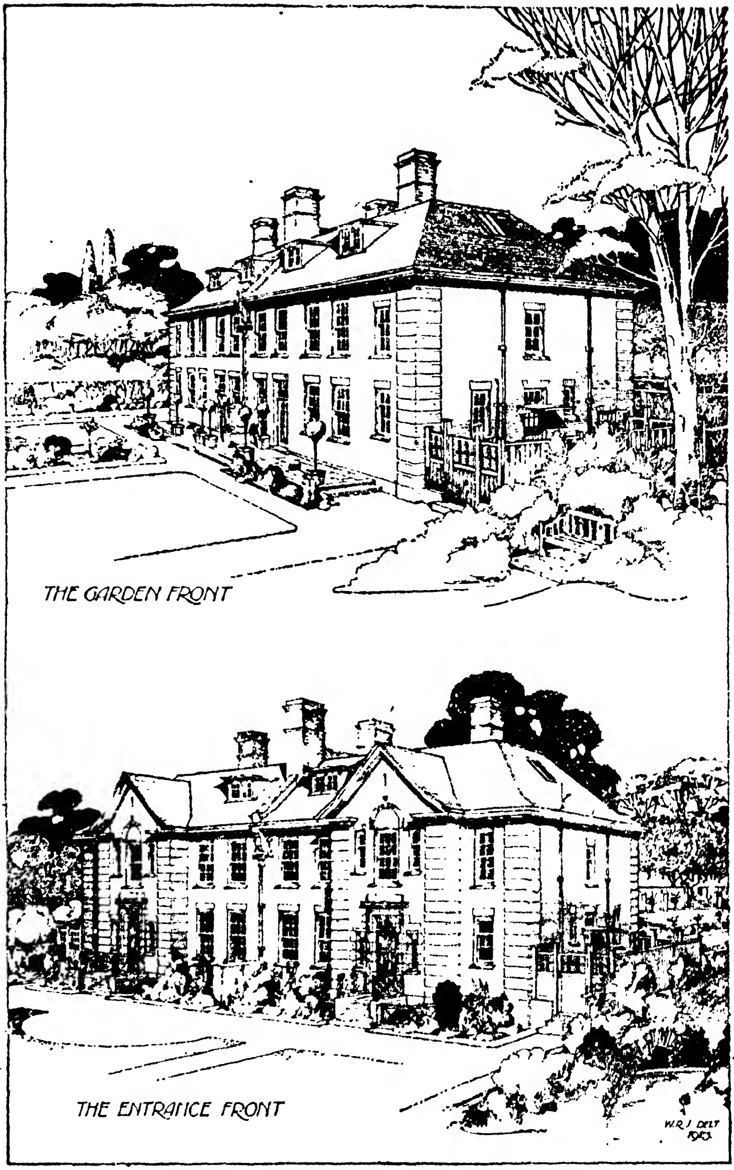

VIEWS OF THE SEMI-DETACHED HOUSES

ARCHITECTURAL BUILDING CONSTRUCTION

A TEXT BOOK FOR THE ARCHITECTURAL AND BUILDING STUDENT

BY

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AND

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M.Sc.Tech., M.I.Struct.E., F.I.San.E.

Second Edition
(Revised and Enlarged by F. E. DRURY)

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GENERAL PREFACE

IN writing and illustrating the series of works on Architectural Building Construction of which this is the second volume, the authors have been actuated by the desires and objects which are briefly set out below.

That there are many existing books on Building Construction is a well-recognised fact; that some of them have excellent matter, and others have good illustrations is also duly acknowledged, but from a long experience in the practice of Architecture, both in England and the Colonies, and many years of teaching architectural principles and the science of building construction, the authors have been forced to the conclusion that something more in the way of text books is needed for the following reasons.

1. Building Construction should not be divorced from the Principles of Architectural Design. Although it is sometimes true that we find an Architect who can design pleasing structures with little or no knowledge of building construction, it is an undoubted fact that a fine conception of noble architecture must be based upon an intimate and complete knowledge of the proper use of materials, the scientific and fit assembly of the varying units, and an honest and conscientious co-ordination of the work of Architect, Builder and Craftsman.

It may be argued that with the present day use of steel and reinforced concrete, together with other modern materials and methods, we are able to construct some most extravagant fancies in architectural design, which a few years ago would have been quite impossible. Whilst this is quite true, and illustrates the age in which we live, it is also true that the very great majority of our buildings to-day are still erected with the staple materials, such as concrete, brick, stone and timber.

2. For the creation of good architecture it is necessary to study the work produced by our predecessors, and not only the work of ancient civilisations and mediæval peoples, but the best work of more modern architects must be examined. This study is rendered comparatively easy of acquisition through the rapid and cheap facilities offered for travel, and the many excellent books and illus-

trations which are constantly being published. Attention might here be drawn to the publication entitled, *The Development of English Building Construction*, written by Mr C. F. Innocent, and forming one of the volumes of The Cambridge Technical Series; a perusal of this book will be found both interesting and helpful. Is it possible to apply this method to the study of Building Construction? The authors have been impressed with this idea, and have endeavoured, with some success, to carry it out in their teaching. They have, however, found that in the earlier stages of education this must not be unduly pressed. For elementary students, the teacher should, to some extent, be dictatorial, and whilst selecting a well-proportioned and designed study as an example, should insist upon the construction being shown in a definite manner, although he knows that infinite variety, both in design and construction, is possible. With the more advanced student greater latitude is desirable, and in fact necessary. The authors have, therefore, impressed a certain amount of individuality in the subjects of the first two volumes, but they intend, as far as possible, in the third volume to select examples of established taste and architectural value to illustrate advanced principles of design, maintaining in some cases the constructional details given them by their designer or constructor, but in others, adapting the construction in accordance with modern methods and the more extended use of machinery.

3. Building Construction has more generally been presented to the student in the form of isolated examples, which have no relation whatever to each other, and thus the knowledge obtained cannot be applied to the actual design of a building, even of the smallest dimensions, until a very much later date. Modern methods of teaching demand a greater cohesion. The authors have endeavoured during their teaching experience to obtain or formulate one building into which all the various items comprehended in each year's work could be fitly placed, but after many attempts it was found to be impracticable, and therefore two buildings were arranged, which embody, with few exceptions, all the items necessary for an elementary knowledge of building construction, thus enabling "teaching from the structure itself to be adopted rather than the selection of isolated examples on account of their simplicity".

This method has been adopted in the first three volumes, but whilst the authors disclaim any idea of presenting great architecture, they do claim that the buildings designed fitly express their purpose, and enable them in a more or less pleasing manner to assemble the different units of the building, and at the same time to inculcate a sense of completeness in the student's work.

4. The acquisition of a knowledge of Building Construction should rightly be a plant of slow but sturdy growth, and in the majority of Architectural and Building Schools the course of instruction covers a period of from three to five years. The first volume of this series is designed to meet the needs of the first year student, the second volume will provide more than is generally required for a second year course, while the third volume will cover a large field of advanced work.

5. The authors have often felt that the ordinary orthogonal presentation of examples of building construction does not sufficiently convey the solidity of the object to an elementary student, and as it is not possible for each student to have, or to make, models of the different units for himself—although such a course would greatly make for efficiency of study—the illustrations have to a large extent been shown in perspective, isometric or pictoral projection. Photographs might, and in some cases will, be used, but the camera, whilst giving a faithful representation of the object, cannot be used to show the construction of hidden parts. On this account dissociated isometric and oblique sketches have been freely used with some slight shading to indicate differing planes, but cast shadows have generally been avoided as tending to obscure the construction, which it is desired to show in the clearest possible manner.

It is strongly recommended that in all Architectural and Building Schools correct scale models—about half full size—of the different items should be made in such a way that the parts may be dissembled, and that the student should be encouraged and advised to study and measure these carefully, and make the usual orthogonal drawings, which are, after all, the media through which Architect, Builder and Craftsman convey their ideas and wishes to one another.

It is necessary to impress strongly upon a student in the early stages of his work, that his knowledge must be presented in a clear and unmistakable way and with some architectural character and

students should be encouraged carefully to complete all their drawings with full naming of parts, references, and adequate dimensions, and to ink-in and colour, or otherwise distinguish, the materials of construction. They will thus acquire the habit of thoroughness, which is of inestimable value to both draughtsman and craftsman.

In conclusion, the authors' chief endeavour has been to make these volumes of primary importance to students—architect, builder or craftsman—and since in this study, at least, they all meet upon common ground, although each with different aims and objects in life to accomplish, yet, each finding help and guidance herein, there is an augury of the future happy relations which should exist between those engaged in all the branches of the practice of architectural building.

W. R. J.

F. E. D.

June 1916

PREFACE TO VOLUME II

IN compiling this volume it was necessary for the authors to give careful consideration to the mode of treatment. At least two courses were open to them, viz. the illustration of methods of construction applied to isolated building details, by selecting examples having no definite relation to or embodiment in any one building, or, to continue the method adopted in the first volume of this series, and endeavour to relate all the items of construction which it appeared desirable to illustrate and discuss, and to apply these rationally within the boundaries of one or more buildings of a definite character.

The latter course commended itself to the authors and they decided to proceed on this basis. Two buildings of different character were selected in order to avoid the aggregation of conflicting details and doubtful combinations of materials which would, of necessity, render a single building very elaborate and complicated, if designed to contain them.

This volume contains the treatment of such parts of the two buildings as can reasonably be placed before a good second year student in an average school of building or architecture, and the remaining study, for the complete consideration of the two buildings, is given in Vol. III.

One of the buildings belongs to the class generally known under building regulations as "domestic buildings", while the other belongs to the division known as "buildings of the warehouse class".

A certain amount of overlapping in the preparation of details under the conditions of the treatment selected is inevitable, but it was found convenient and practicable to design two structures which are fairly typical of their respective classes, while embodying the features desirable for study.

These buildings are:

(1) A semi-detached suburban house.

(2) A town warehouse.

The architectural treatment of these buildings in plan and elevation has been developed with the intention of illustrating as varied

a range of constructional examples as possible. It cannot be maintained, however, that all the variations of detail suggested could be embodied or economically used in one building, but each example suggested may be fitly employed as an alternative to other forms of construction in a building of the type to which it refers.

The question of cost has not been overlooked by the authors, but they have not allowed this point to interfere with the objects in view, viz. to illustrate and explain a number of sound and standard methods of construction, generally suited to the class of buildings under consideration.

First cost is not the only point to observe, because it frequently happens that an apparently costly structure is so economical in maintenance that it may ultimately become cheaper and more serviceable than a building of a more meretricious character, where a low first cost appeared to ensure economy.

Furthermore, the mere fact that a building has been erected with costly materials and supplied with much added decoration does not necessarily mean the production of a building of architectural value. Many wayside cottages have that elusive charm, which we know as architecture, and which is very often missing in some of the large town buildings. It should be the business of every student to endeavour, for himself, to find that secret by which the smallest building, by correctly expressing its functions, may, equally with the large and noble, take its place as a work of architecture.

The authors desire to record their indebtedness to all who have been kind enough to supply information, and to take an interest in the preparation of this volume.

W. R. J.

July 1922 F. E. D.

In the present edition the subjects of study have been rearranged and many revisions and additions to the text have also been made.

It is hoped that this change will be an advantage to teachers and students in meeting the needs of grouped course instruction.

Thanks are hereby accorded to Mr Norman Keep, F.R.I.B.A., and Mr R. A. Bix for their valuable assistance in preparing diagrams for this volume.

F. E. D.

April 1936

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Special Plates:

General Contract Drawing of the Semi-Detached House . *in pocket*

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DESCRIPTION OF THE BUILDINGS, THE CONSTRUCTION OF WHICH IS TO BE STUDIED IN VOLUMES TWO AND THREE

The House

THE house designed for the purpose of this volume is the right hand one of a pair of semi-detached suburban houses; it is illustrated in the working drawing supplied in the pocket of the binding.

The plot of land to contain the two houses has a frontage to the street of about 100 ft. and a depth which depends upon the conditions of the locality and the garden space decided upon at the back of the property. The front of the house faces north-east and is intended to be set back about 25 ft. from the roadway.

The house itself has a frontage length of 42′ 3″ and a depth of 33′ 6″. There are no out-buildings at the rear. The main entrance is at the front and is emphasised by a gabled feature projecting 3 ft. from the main face.

The house is two storeys in height, the ground floor being 10′ 9″ high from floor to floor, and the first floor 10′ 3″, while an attic storey with a height of about 9′ 4″ is arranged in the roof.

The walls are of brick, built as a cavity wall, with an external thickness of 4½″ in Flemish bond and an internal thickness of 9″ in English bond, and care has been exercised in arranging the sizes of rooms, door openings and window openings, so that ordinary brick sizes are obtained with little or no special cutting or broken bond. The main quoins of the building are emphasised by the use of pilasters, formed by slightly projecting and recessing certain brick courses.

The window openings have moulded brick cills and joggled brick lintols, and are fitted with wooden cased frames and sliding sashes. The frames are set 3″ from the outside face of the wall, the openings being formed with square stopped jambs, and the windows surrounded by moulded wood architraves, abutting upon the oak cill. A tradesmen's entrance doorway at the side is provided with a lead covered projecting hood and a glazed door with a fanlight over.

The main entrance doorway, set in the centre of the front projecting gable, forms a focal point of interest to the building. It is approached by a short flight of steps across an open area, which is formed to obtain light to a small basement room, and is guarded by

short wing walls surmounted by wrought iron railings. Similar railings guard the open areas on both sides.

The doorway, which is flanked on either side by small windows, is finished with moulded stone architraves, cornice and blocking course and is fitted with a solid door frame, double margined door and fanlight with bronze grille. The small side windows have oak frames with metal casements.

The garden at the back of the house is approached from the drawing room by means of French casement windows giving access to a small paved terrace.

The main walls are surmounted by a built up wooden eaves cornice finished with half round eaves gutters, connected to down pipes, one of which discharges into a water butt upon the terrace for use in the garden.

The roof is covered with plain tiles, and is hipped at the external angles, the front projection being finished with a gable. Owing to the width of the building, it is not desirable to carry the roof to a ridge, hence the upper part is kept down and a lead covered flat roof is formed, which affords several opportunities for constructional examples. Three lead covered dormer windows break the roof surface, and for purposes of illustration skylights are shown to the cistern room and to the attic stairs, although the authors deprecate the use of skylights, where vertical windows can and ought to be used.

The chimney stacks are of brick, with oversailing brick and tile courses to provide a capping and necking to the stack.

The internal accommodation of the house is as follows:

On the ground floor. An entrance hall, 17′ 6″ × 14′ 10½″, contains an open well stair leading to the upper floor, a straight flight stair with winders to the basement, a recess for the telephone, a small lobby and a lavatory. The hall has a concrete floor surfaced with marble tiles, and the walls are finished in plaster above a panelled teak dado, which is in harmony with the design of the teak mantel surrounding the stone arched fireplace.

The dining room, at the front, is 15′ 9″ × 14′ 0″, and the drawing room, at the back, 16′ 7″ × 15′ 9″; the latter overlooks the garden. On the left of the hall two doors provide access to these rooms. The rooms are divided by a trussed timber partition containing a pair of folding doors. The fireplaces and windows of these rooms are subjects of special treatment in the design and construction.

The kitchen is entered from the hall and is 14′ 10½″ × 12′ 0″. Its windows overlook the garden and the room contains a kitchen range, a gas cooker and a dresser, this last being illustrated in detail. A scullery, 8′ 3″ × 7′ 11″, opens off the kitchen and is fitted with an earthenware sink and teak draining boards. The larder, 8′ 3″ × 3′ 6″, is entered from the scullery. A semicircular archway from the hall

leads to the tradesmen's entrance, the lobby thus formed giving access to a w.c. and coal store, while a bicycle or tool store entered from the yard at the side of the house completes the accommodation provided on the ground floor.

On the first floor there are two double bedded rooms and two rooms for single beds. They are respectively 16′ 7″ × 15′ 9″; 15′ 9″ × 14′ 0″; 14′ 10½″ × 12′ 0″ and 14′ 0″ × 8′ 3″. The three larger rooms each have fireplaces and permanently fitted wardrobes. A lavatory and w.c. and a linen store are entered from the landing, and a bathroom and store cupboard are placed over the scullery and tradesmen's entrance.

The attic floor contains three bedrooms, one of which is sufficiently large to accommodate twin bedsteads, while a large box room and a cistern room are also provided.

Hot and cold water services are provided to the bathroom, lavatories and scullery sink, the hot water storage cylinder being placed in a cupboard entered from the bathroom on the first floor.

The basement consists of one room under the entrance hall and affords a number of examples in the construction of basement walls. It is lighted from the areas alongside the front entrance steps.

The Warehouse

The warehouse building is intended to occupy a site between other buildings on each side of it. It has a frontage to the main street of 54′ 6″, a depth of 64′ 6″ and a frontage to the back street of about 69′ 6″. Access is obtainable from both streets, but no side lights are possible except by the formation of open areas.

The accommodation required is provided on three floors, while about half the area is slightly excavated in the front for a basement. This is rendered economically possible by a fall of 4′ 0″ in the original surface of the ground from back to front of the site.

The main building consists of a large room, about 60′ 9″ long by 36′ 9″ wide, on each of the three main floors. A series of six steel stanchions or cast iron columns on the ground and first floors divide the floor area into twelve bays, each about 15′ 0″ × 12′ 0″, and various alternative methods of dealing with the construction and calculations necessary for these floors are illustrated and discussed. The second floor has no intermediate supports, but is covered by a slated roof supported on queen-post trusses.

Assuming that it may be desirable under some conditions to have the first floor free from intermediate supports, it would be necessary to introduce large main girders across the full breadth of the building. Built-up plate girders have therefore been included in the scheme for the consideration of the student.

In order to gain access to the rooms at the various floor levels a separate staircase wing is arranged alongside of the main building.

The principal entrance is placed on the ground level of this building and a tiled vestibule and entrance hall lead to a stone stair which is carried to the top of the building. The large rooms of the main building are entered through slightly recessed doorways, fitted with teak fire-resisting doors, opening outwards.

Lavatories are arranged upon the main and intermediate landings, providing two w.c.'s and two lavatory basins on each level. Accessible from the landings, and behind the stairs, a space is provided for a lift or hoist, although the construction of this feature does not form a part of our study.

Entered from the back street and occupying the remainder of the back portion of the site a loading and packing shed is provided about 32′ × 25′. This contains a sunk loading dock for carts to back into at the level of the street, and a back entrance for employees and a timekeeper's office are also provided.

The loading shed is roofed with corrugated galvanized iron or pantiles supported on open steel trusses, and contains a fixed skylight. A doorway at the back of the loading shed leads, by way of a flight of stone steps, to a small open yard which has an exit to the front street.

Communication between the loading shed and main ground floor room is obtained by means of a large opening spanned by a bressummer, several alternatives for which are illustrated, and by a doorway fitted with a sliding fire-resisting door. The larger opening would be closed by fitting a steel revolving shutter under the bressummer.

Only a portion of the basement is excavated, but the room so obtained is 36′ 0″ × 29′ 3″ and is lighted by windows from the main street.

The stone stairs, already mentioned, are carried to the level of the main roof, and a portion of the staircase wing is carried to a higher level, in order to provide adequate headroom for the lift gear. This part of the building is enclosed by a lead covered flat roof.

Externally, the main front of the building, including the staircase or lavatory wing, is to be carried out in stone. The design of this façade has been allowed to express the plan of the building, and provides suitable masonry examples for the student.

The main façade consists of a basement and ground storey, with strongly marked and channelled horizontal joints; the basement windows are protected with wrought metal grilles, while the ground floor windows are surmounted with segmental arches with channel jointed voussoirs and triple key blocks, and are fitted with wrought metal window frames. A slightly projecting string course at the first floor level forms a base upon which a simple application of one of the Orders of Architecture is erected. This consists of Doric pilasters carried through the height of the two upper floors and finished with

an entablature consisting of architrave, frieze and cornice. The windows of the first and second floors are placed between the pilasters, surrounded with moulded stone architraves and fitted with wrought metal window frames, similar to those on the ground floor. Amongst the subsequent illustrations in this volume an alternative design is given, showing the space between the pilasters filled in with cast iron panels in lieu of stonework. Above the main cornice the façade is completed by a broken parapet, which serves to cover the end of the main roof. A masonry chimney stack in the party wall contains the flues from the basement and ground floor fireplaces.

The front of the staircase wing is kept quite distinct from the main façade. The main entrance doorway at the ground level is surrounded with a sunk panelled architrave and finished with a small frieze, tablet panel, cornice and blocking course. The lavatory windows are grouped together vertically in pairs and the channel jointed ground storey and string course are carried through this side wing and serve to bind it to the main building. Chamfered projecting quoins accentuate the angle and are returned along the side wall and enable a finish to be made to the stonework of the front.

The side wall of the staircase wing is built in brickwork in English bond, and although irregularly broken up by the staircase and lavatory windows is bound together and strengthened by the horizontal line of the cornice.

The elevation of the main building to the back street is intended to be of brickwork in English bond, with the large window openings finished with ashlar stone quoins, although an equally satisfactory finish would be obtained with plain brick quoins, as suggested for the side windows overlooking the roof of the loading shed, on the first and second floors of the main building. The ground floor windows are spanned by segmental stone arches with stepped extrados and key blocks, whilst sunk panelled cast iron lintols are used for the upper floor windows. Lok'd bar metal frames with ventilating lights are fitted to the openings, but alternative treatments are suggested elsewhere.

The back entrance is shown with a plain flat stone architrave and moulded cornice, and the doorway is fitted with double folding doors and glazed fanlight, while the entrance to the loading dock is spanned by a semi-elliptical gauged brick arch and closed with collapsible steel gates.

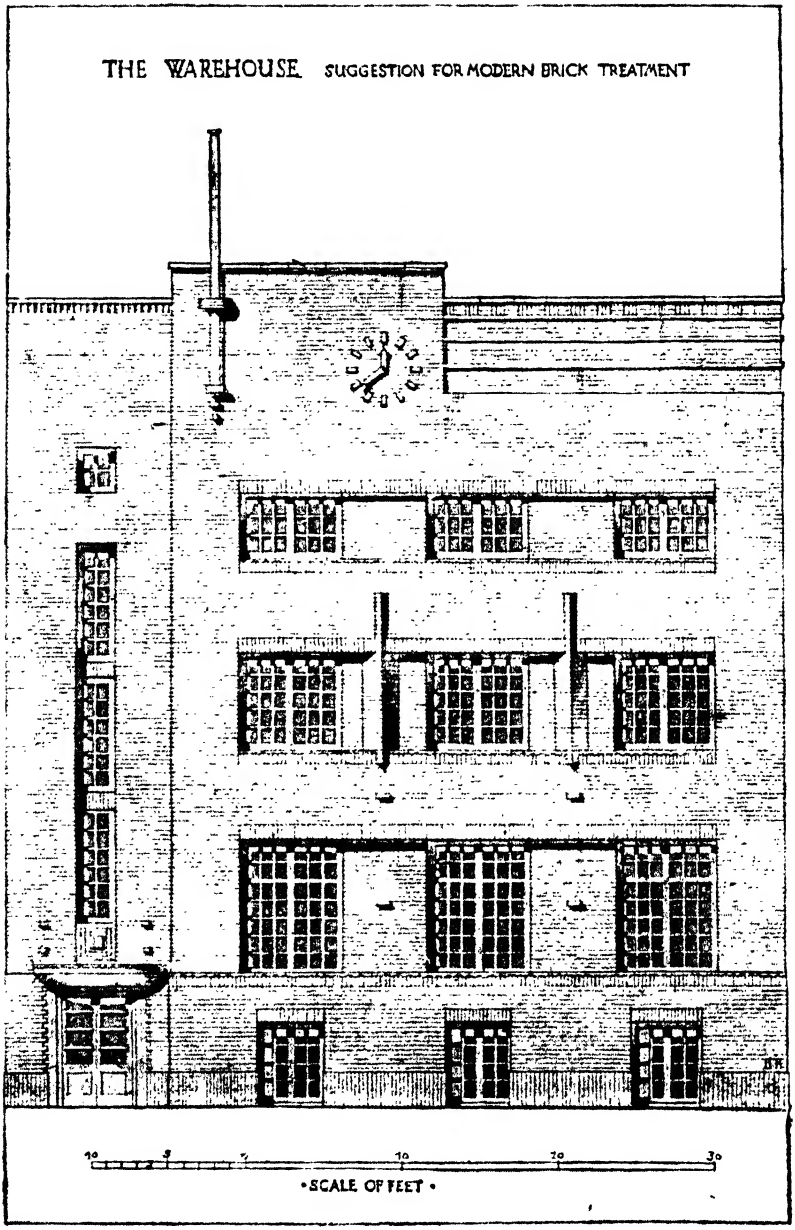
So far as applicable or expedient for the authors' purpose the provisions and regulations of the London Building Acts have been adhered to, but these have not been allowed to interfere with the proper elucidation or development of the scheme of constructive examples embodied in the building.

Alternative Brick Façade

The main façade of the warehouse might appropriately be constructed of brick in lieu of stone. A suggestion for a brick façade is given in the frontispiece of this book for the consideration of students and teachers.

The development of this brick façade might be treated as a problem in design for students specially interested in brickwork.

The suggested design—or the student's own production—would make a useful feature for individual study. For the designer the selection and use of multi-coloured bricks or selected and grouped bricks of varying colour may be introduced. For the constructor the planning of voids and solids to allow of unbroken bond, and for the craftsman in brick the actual detailing of the bonds for practical purposes.



THE WAREHOUSE SUGGESTION FOR MODERN BRICK TREATMENT

CHAPTER ONE

BRICKWORK

Foundations and Basement Walls

In Vol. I a study was made of the arrangement of foundations suitable for small buildings erected on ordinary dry soils and requiring little excavation.

The term "standard foundation" was used to denote the usual form and proportions adopted; such foundations are only suitable for favourable conditions and in structures of normal size.

Readers should observe that even the "standard" foundation, still required by most building regulations, is found unnecessary for many light buildings. Dwelling houses are commonly erected without brick footings to the walls, the latter being erected directly upon a concrete bed of the necessary width.

For buildings of the warehouse class, special consideration must be given to the problem of reducing the pressure on the foundation soil to a safe value per unit of area.

1. Function of a foundation. The purpose of a foundation is to receive the loads from walls and pillars and to transmit these to the earth without undue or unequal settlement.

Ordinary clay soils or confined sand may safely bear 2 tons per sq. ft. of foundation area and a building of two or three storeys in height may generally be erected thereon with perfect safety, if the standard foundation be adopted.

For taller buildings an estimate must be made of the total load likely to be borne, and the breadth of the concrete bed increased if necessary to reduce the pressure to the allowable value prescribed by local regulations, or where these do not exist to such value as experience has shown to be safe and economical.

2. Spread foundations. In many cases it will be found necessary to spread the foundation concrete beyond a width of $2T + 12''$, where T is the thickness of the wall in inches at the base. In such instances the concrete may be kept of an economical depth and made to resist bending on the projecting arm by embedding steel beams transversely, at intervals of $1'\ 6''$ to $2'$, across the full breadth of the base, or may be reinforced by embedding $\frac{5}{8}''$ to $\frac{3}{4}''$ round bars with hooked ends in a similar way near the base of the concrete, and overlaying these with $\frac{1}{2}''$ bars longitudinally at the overhanging parts only. The

former bars convert the foundation into two reinforced cantilevers with the steel taking tension on the under side, while the upper layer of bars distributes the pressure over the length. According to size and conditions the transverse bars will be placed at 4″ to 8″ centres and the longitudinal bars at 6″ to 12″ centres.

3. Essential points in foundation and basement construction. The following are essential matters in the practical preparation for foundation and basement work:

(*a*) Seek a natural foundation which will satisfactorily support the load with the least artificial preparation and not unduly subject to disturbance. This may mean that layers of unsatisfactory earth must be cut through and the foundation bed made deeper in order to gain the desired result.

(*b*) See that the natural foundation is dry or take measures to maintain dryness, at least of the interior. Wet soils may need to be drained, or if this is impracticable, temporary dryness may be obtained by pumping, and some permanent means adopted for damp proofing the walls and floors in contact with the earth (see clause *d*).

(*c*) Proportion the size of the foundation to the bearing power of the soil if an increase of size beyond the standard foundation is necessary. Otherwise adopt the "standard".

(*d*) If a basement is required and ground water cannot be eliminated from the site, or, if the ground slopes downwards towards the walls and tends to absorb and pass surface water thereto, provide adequate damp-resisting construction throughout the basement floor and walling; see paragraphs 13 and 14.

4. Ground water. In Vol. I and also in the last clause a reference has been made to "ground water". This is water which exists in soils due to the following causes:

(1) Most soils are porous and water percolates through them until arrested by a bed of clay. Suppose a cup-like depression exists in this bed, then water may collect until full, when it overflows and spreads into the surrounding soil. Such a depression may be of large extent and retain considerable quantities of water and if a building foundation penetrates the depression it is difficult to get rid of this ground water. Drainage of the site at a low level is the proper procedure if means exist for disposing of the drainage.

(2) If near to a river and the banks of the stream are of porous soil, water spreads through the pores to the level of the water on each side and, by capillary attraction, rises to a higher level and saturates the soil. In addition, the water level fluctuates with the rise and fall of the river. Buildings on or near banks of streams are liable to damp basements and foundations due to this cause.

Other examples could be quoted, but the above will suffice for the present purpose.

5. Ground air and moisture. The pores or voids in soil, above the level of any ground water, are filled with air containing quantities of carbon dioxide and other gases, in some degree injurious to health. Water vapour is also enclosed with this air where it lies over damp soils, rendering the earth moist and cold.

Such ground air and water vapour is not stationary, but is expelled from the ground by rises in the level of the ground water and by the expansion of the air due to increase in temperature. When the ground water falls or the temperature decreases, air above the ground is drawn into the soil, becomes charged with gases and vapour and would be again expelled under suitable conditions.

Air and water vapour thus expelled quickly disperses if discharged into the open air, but if allowed to enter unventilated enclosures under ground or basement floors, it accumulates, the atmosphere becomes suited to the development of a decay in the floor timbers, known as dry rot, while if the air can leak into habitable rooms it may cause injury to health.

6. Cold sites. Wherever water is retained in the ground, unless at a considerable depth below the foundation, the temperature of the site is liable to be kept low, the atmosphere surrounding it damp, and the building cold.

Where such sites are used for the erection of dwellings they need careful treatment with the object of removing the cause or, as an alternative, of preventing ground air, ground moisture and water, or surface drainage from penetrating to the interior of such buildings.

In exposed and cold situations moderately thick walls are necessary for healthy buildings, whatever material or method of construction is adopted. The studies included in this volume are intended to be suitable for a first class building of each of the types under consideration.

7. Basement. A basement room is one which has its floor level below that of the ground immediately adjoining. The term is sometimes used to describe the lowest storey of a building but this is only justifiable when dwellings have some of their habitable rooms with their floors below the ground level. Many modern dwellings have no such rooms and the lowest storey is then named the ground floor storey.

Basements are adopted in each of the buildings selected for study and provision for damp-resistance suited to the conditions is considered in paragraphs 13 to 16.

8. Basement walling. This term refers to walling above the foundations and below the ground floor; much of it may be in contact with the soil and may thus require special treatment to prevent the absorption of moisture.

The moisture may be due to percolating rain water or to soil in contact with ground water.

9. Foundations to warehouse. The warehouse under consideration is a four storey building, and because of its height and weight will require larger foundations than those employed in previous studies. On good soils it may happen that the standard proportions still serve, but the width of the concrete should be checked, because its increase in breadth is not directly proportional to the thickness of the wall which it supports.

Most building regulations require a minimum thickness of walls for various stages in the height of a building, offsets being provided at floor levels, and the walls increasing in thickness inwards towards the base. The footings are twice the thickness of the wall at the base, but the concrete does not project in proportion, 6″ being usually adopted for all cases. Thus, if an 18″ wall supports a load of 16 tons per foot of length, the standard concrete base will be 4 ft. wide and thus provide 4 sq. ft. of base area per ft. run. The pressure on the earth would then be $\frac{W}{A}=\frac{16}{4}=4$ tons per sq. ft.

If a 36″ wall supports 32 tons, the base will be 7 ft. wide and the stress on the earth $\frac{32}{7}=4\frac{4}{7}$ tons per sq. ft.

Thus the pressure per sq. ft. becomes greater as the wall increases in thickness, assuming that the increase is proportionate to the load.

10. Thickness and projection of concrete. If the projection of the concrete were proportionately increased in order to keep the pressure per sq. ft. constant for one class of wall, a greater depth would become necessary to resist the upthrust from the ground, or some reinforcement would be provided to accomplish the same purpose.

The minimum depth of plain concrete may be determined by the following method, based on the graphical procedure adopted in Vol. I. In detail No. 1 let

T = thickness of wall at base,

D_F = depth of footings,

D_C = depth of concrete.

Each step of the footings projects $2\frac{1}{4}$″ and is 3″ deep, hence the total projection and depth of footings are proportionate. By similar triangles

$$\frac{D_F}{\frac{T}{2}}=\frac{3}{2\frac{1}{4}},$$

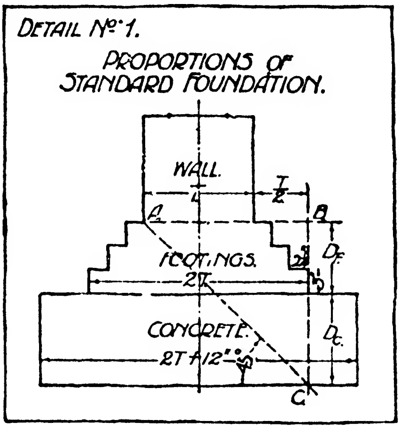
$$\therefore\ D_F=\tfrac{2}{3}T.$$

Employing the 45° line for determining depth, $AB=BC$.

$$\therefore\ D_C+D_F=T+\frac{T}{2}.$$

But
$$D_F=\tfrac{2}{3}T,$$
$$\therefore\ D_C+\tfrac{2}{3}T=\tfrac{3}{2}T,$$

and
$$D_C=\tfrac{5}{6}T.$$



It is proposed to employ this proportion for walls up to 2′ 3″ thick; the concrete then requires to be $\frac{5}{6}\times 27=22\frac{1}{2}''$ deep. Beyond this dimension, roughly 2 ft., the thickness may be kept constant.

If calculations show that a greater width of concrete is required than would be provided by a standard foundation one of the methods of strengthening already referred to in paragraph 2 should be adopted; it may then be possible to decrease the thickness.

WALLS AND FOUNDATIONS TO WAREHOUSE

11. Warehouse walls. On reference to the general plans of the warehouse it will be seen that this building is exposed on three sides while the fourth might adjoin another building and become a party wall.

A "party wall" is a wall dividing two buildings adapted for use by different occupiers and jointly belonging to the respective owners of the two buildings.[1]

The front, back and party walls are joined to others at their angles only, but the external wall parallel to the party wall receives

[1] The student should consult the complete definition of "party wall" given in the Model Bye-laws of the Local Government Board and in the London Building Acts.

support by being bonded to the return wall of the staircase and hoist enclosure.

The building regulations of the London County Council are too extensive to quote here, but taking these as a guide for determining the thicknesses of the walls,[1] the three external walls should be 1′ 10½″ thick at the basement floor, while the party wall should be 2′ 3″ thick. This difference is due to the greater unsupported length of the party wall as compared with those of the three external walls.

On examination of the sections of the building, shown on the general plans, it will be seen that these thicknesses are diminished at each floor level until a minimum of 13½″ is reached for the top storey.

The front wall of the warehouse is of greater thickness than the regulations require, because of the architectural treatment adopted; see Chapter on Masonry.

12. Site of warehouse. The site is on sloping ground, which rises 3′ 9″ from the pavement level in the front street to the pavement level in the back street.

To avoid undue excavation, and to utilise the site economically, a front basement room is provided across the breadth of the building and half the depth of the site.

In some instances the material excavated to provide space for the basement might be used for filling in some of the space between the ground floor and the natural surface where no basement is required.

In this case it is scarcely feasible, the slope and available space being small; further, it is not desirable to construct the back portion of the ground floor on filled ground, because, although the material might be of a satisfactory nature, adequate consolidation during the period of building is not readily obtained. The foundation treatment due to the sloping site is given in Vol. III.

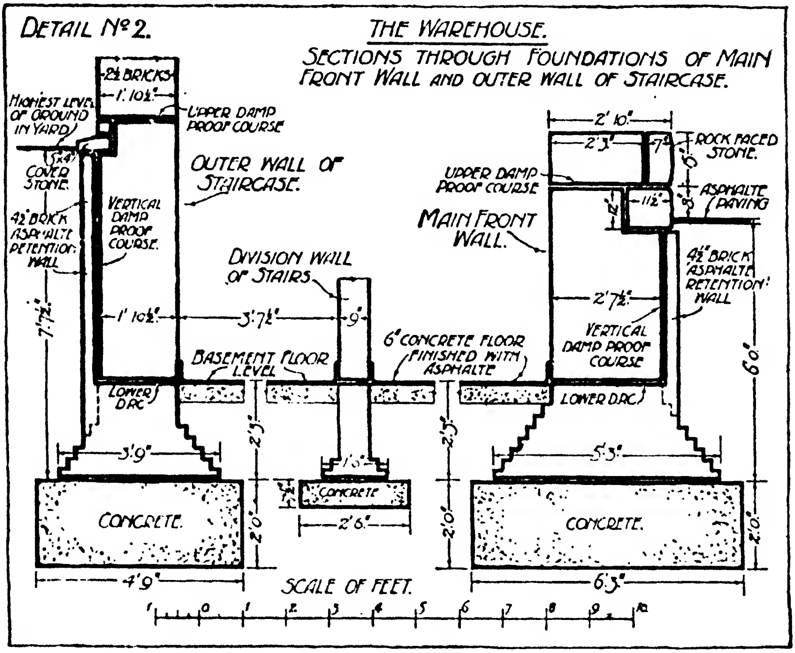
13. Damp proofing arrangements to warehouse walls. To exclude damp where no basement exists, the usual horizontal damp proof course is inserted in the external and internal walls, at least 6″ above the ground level.

If the adjoining property has no basement or the wall is an external one, *e.g.* the external staircase wall, two damp proof courses are necessary, one being inserted at the basement floor level to prevent absorption from the foundation and another 6″ above the ground level to prevent absorption from surface soil

[1] See also L.G.B. Model Bye-laws.

or surface drainage, as shown on detail No. 2. These horizontal courses are connected by a vertical damp proof course—see next paragraph.

In the case of very damp soil—unless the concrete floor to the basement is specially damp-resisting—the lower damp proof course is wisely carried right across the floor in the form of a ½″ surface covering, gritted with coarse sand to provide a non-slippery, while impervious, floor.

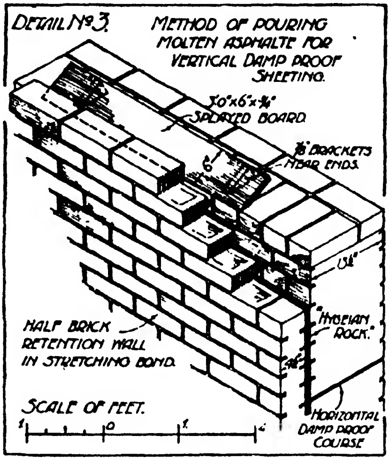


14. Vertical damp proof sheeting and retention walls. It would be useless to provide two horizontal damp proof courses, as described in the previous paragraph, if damp earth were left in contact with the intervening wall without protection. Hence a vertical sheet of asphalte or other suitable material[1] is inserted near the outer face of each exposed wall. An efficient method of doing this is to build a 4½″ wall in stretching bond against the main wall, leaving a ½″ space or cavity between the two and open horizontal joints ½″ deep on each side of the cavity. As the walls are erected, either molten asphalte, or Hygeian rock,[1] is poured in at intervals of three to four courses—see sketch on detail No. 3; the asphalte

[1] See Chapter on Materials.

quickly solidifies and provides an effective bond between the facing and main wall.

The half brick wall used in such a manner is named a "retention" wall.



15. Basement of the house. The house selected for study is provided with a basement placed under the hall—see general plans.

This basement is lighted by two windows opening into an "area" in front, which is an open space formed by excavating to a suitable depth below the basement floor level and wide enough to admit adequate light on each side of the flight of entrance steps.

16. Damp proofing of basement to the house. The basement is protected against damp on the three vertical walls in contact with the earth in a similar manner to that described for the warehouse, a $\frac{1}{2}''$ sheeting of Hygeian rock being poured between the $13\frac{1}{2}''$ basement walls and a $4\frac{1}{2}''$ retention wall; see detail No. 4. At the bases of these walls this sheeting is connected to a $\frac{1}{2}''$ horizontal layer of similar material placed between the brick courses at the floor level, and projecting slightly over the 6″ concrete floor. The floor surface is formed by a $\frac{5}{8}''$ coating of waterproofed cement mortar consisting of one part of Portland cement to $1\frac{1}{2}$ parts of sand, and 2 per cent. of Pudlo[1] measured by volume. A skirting of the same material is carried 6″ up the wall and finished with rounded angles, the two intervening brick joints being raked out to a depth of $\frac{5}{8}''$ to form a key for this skirting.

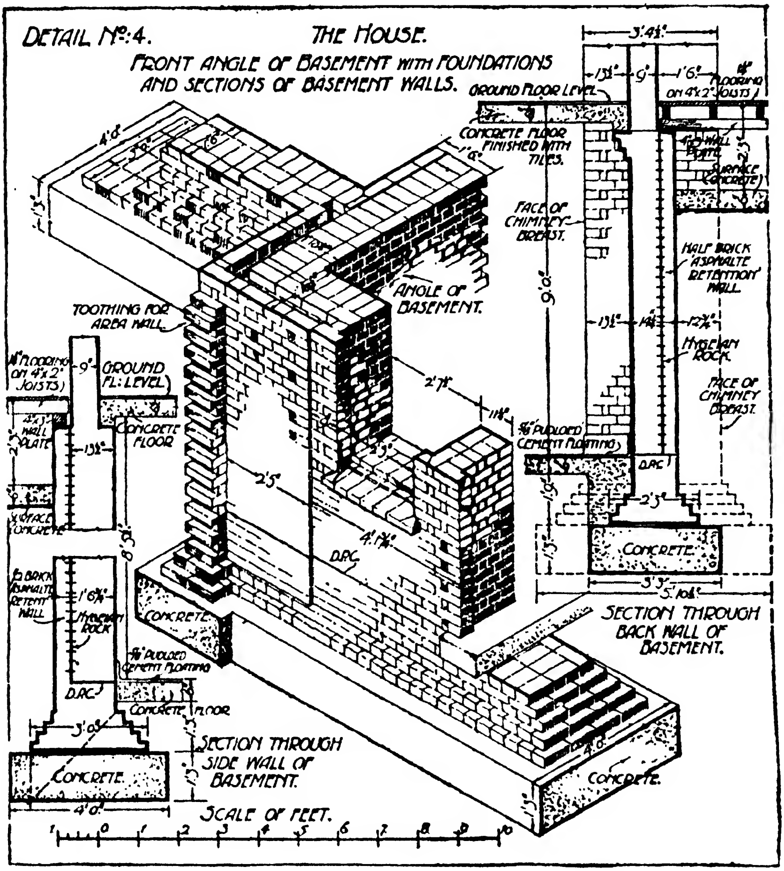
17. Hollow basement walls. Detail No. 4 also shows that the front wall of the basement is constructed in two sections with a space or cavity between them.

The purposes of hollow walls, their construction and the methods of ventilating are explained in the next chapter, commencing at paragraph 35.

18. Foundations to external walls of house. Apart from the basement the main walls of the house have their foundations carried to a depth of 4′ 6″ below the natural ground level.

[1] See Chapter on Materials.

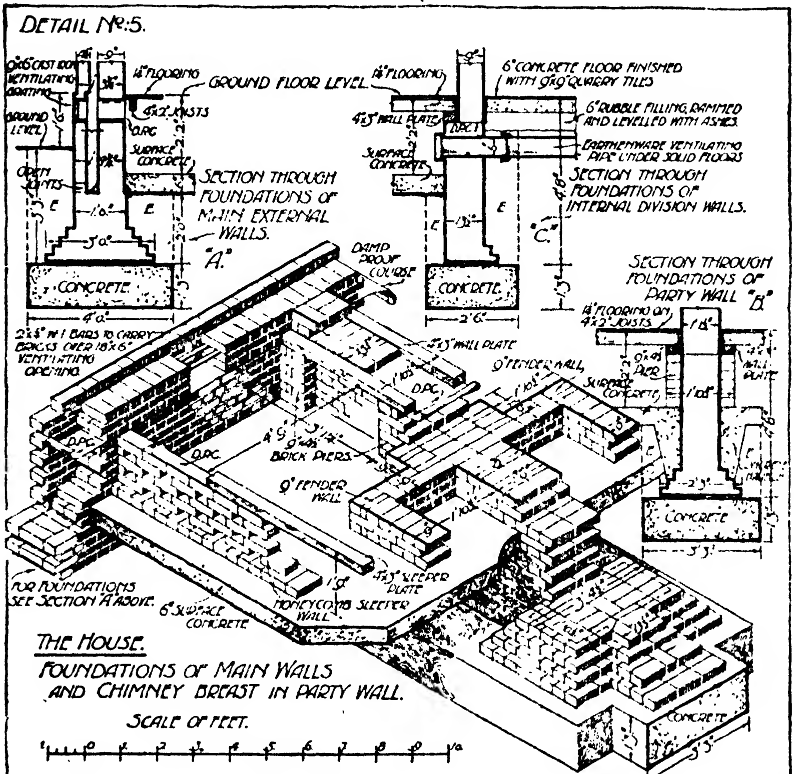
The walls vary from 13½″ to 18″ thick and have foundations of standard width, but the depth of concrete is 15″ throughout to allow footings to commence at one level.



The sections of these walls are shown in detail No. 5. In the external wall at A the cavity is continued 1′ 3″ below the ground, and the foundation walling between this and the footings is solid. The damp proof course is inserted in the inner portion of the hollow wall immediately below the wall plate level and the space between the joists and the surface concrete ventilated by an air inlet through both portions of the wall. The outer opening is guarded by a 9″ × 6″ cast iron air grating while the inner one is unobstructed and spanned by two 2″ × ½″ wrought iron bars to support the brickwork.

19. Foundations to party walls. The party wall at B is 13½" thick, but to support the wall plates which carry the floor joists at the recesses on each side of the fireplaces, pairs of brick piers are erected upon the surface concrete and bonded to toothings in the party wall. This construction is also shown in isometric projection on the same detail.

DETAIL No. 5.



THE HOUSE.
FOUNDATIONS OF MAIN WALLS AND CHIMNEY BREAST IN PARTY WALL.

The damp proof course shown below the wall plate must be arranged to cover the piers in addition to the wall. Building regulations require that no openings be made through party walls.

20. Foundations to internal walls. The section at C is through the internal wall between kitchen and scullery. The floor of the latter is of concrete laid upon "hard core", while the kitchen floor is of timber, hence an offset of 4½" is provided to support the wall plate on the kitchen side and embodies the footings on that side;

a similar wall dividing the kitchen from the drawing room has offsets on both sides which include both sets of footing courses.

The earth under solid floors such as those of the kitchen offices should not be disturbed—except surface soil, soft earth, or material of an insanitary character—below a depth of about 1 ft. from the level of the finished floor surface; 6″ is allowed for hard core to receive the concrete.

The section at C also shows a 6″ earthenware drain pipe to convey fresh air below the solid floor to the space beneath the wooden floor, where ventilation cannot be directly obtained through the external wall.

In this detail the damp proof course is shown turned up against the vertical face of the wall from its horizontal position to the level of the concrete floor; this prevents damp being conveyed through the rubble filling to the brick wall.

21. Re-filling of excavations. In the sections included in detail No. 5 the extent of the excavations necessary for the foundations and the portions subsequently filled in and rammed are indicated by dotted lines. The disposition of the surface concrete should be noted, especially in section B, where this concrete is haunched at its termination to provide direct support from the footings and to avoid a bad joint against the wall through shrinkage and settlement, which would admit ground air.

22. Foundations and footings to chimney breasts. The isometric detail No. 5 illustrates the foundation to the chimney breasts in the party wall. Footings and concrete foundation are prepared to receive the back to back piers which are arched over to form the fireplace recesses and support the chimney breasts. The piers are 18″ wide and project 11¼″ from the party wall; resting on the surface concrete are 9″ fender walls to carry the hearth and floor joists.

The portion of the party wall foundation at D, between the fireplace jambs, is shown 18″ thick; this is reduced at the ground floor level to 9″ thick for the chimney back and forms two offsets for supporting the concrete hearths.

23. Honeycombed walls. Honeycombed sleeper walls,[1] shown in detail No. 5, provide intermediate support to the floor joists; these, together with the fender, party and external walls are provided with damp proof courses under the sleeper and wall plates which receive the floor joists.

[1] See Chapter on Materials.

CHAPTER TWO

BRICKWORK

Construction of Walls

24. Bonding of plain brickwork. In the examples selected for illustration from the two buildings under consideration, no new principles of bonding are introduced but the student should examine the further applications of principles previously explained, in work of greater dimensions, or of different form. The student is advised to set out the bond for alternate courses from the isometric and other illustrations supplied.

In the warehouse, English bond is adopted throughout, but in the house, cavity walls are employed in which the external portion is $4\frac{1}{2}''$ thick in Flemish bond, while the internal portion, $9''$ thick, is in English bond.

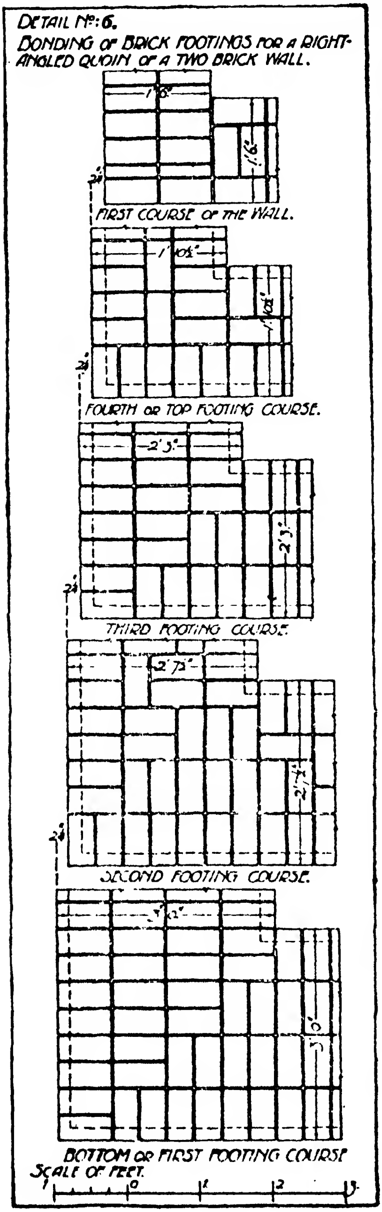
Foundation walling, below the cavity, is built in English bond throughout, while the external portion between the base of the cavity and the ground level is built in stretching bond.

25. Footings. Angle bond. Footings are built as far as possible in heading bond in order to ensure adequate entry of the bricks into the body of the wall, thereby obtaining a more reliable distribution of the load, but there is a difficulty in maintaining this bond at angles and changes of direction. At quoins, the heading bond is broken in one of the courses but maintained in the other, and the strongest arrangement is secured by alternating and interlacing the courses. Detail No. 6 shows the treatment for an $18''$ wall.

An examination of this detail will show that the footing courses bond without closers due to the $2\frac{1}{4}''$ offset.

26. Footing bond in attached piers. Footings for attached piers are shown in fuller detail in Vol. III. In one case a $22\frac{1}{2}'' \times 4\frac{1}{2}''$ pier is attached to the $27''$ party wall and in the other a $2'\ 7\frac{1}{2}''$ square pier is centrally placed within and bonded to the $13\frac{1}{2}''$ cross wall of the basement. An example for reference and guidance is given in detail No. 5 at the footings of the chimney breast to the dining room of the house. All such footings are easy to arrange with $2\frac{1}{4}''$ projections if the walls above are of regular brick sizes.

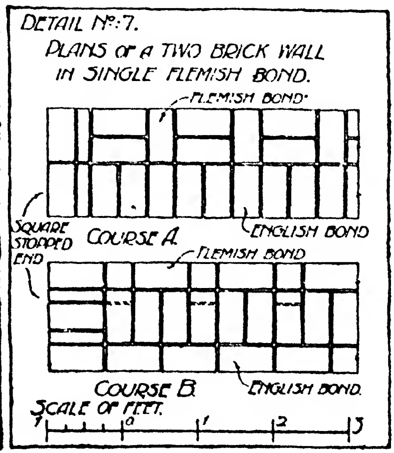
27. Single Flemish bond. Flemish bond is seldom used for external walls thicker than 13½″ because of the deficiencies explained in Vol. I, but if adopted, the Flemish arrangement is usually restricted to the face of the work and the back and body of the wall built in English bond; see detail No. 7. Such work is named "single Flemish" bond. To use the facing bricks economically, half bats, called "snap" headers, are commonly employed, as shown in course B of the detail. The dotted lines indicate the use of ¾ bats in lieu of snap headers, which improves the transverse bond but is not so economical.



DETAIL No. 6.
BONDING OF BRICK FOOTINGS FOR A RIGHT-ANGLED QUOIN OF A TWO BRICK WALL.

Single Flemish bond cannot be applied to walls which are less than 13½″ thick.

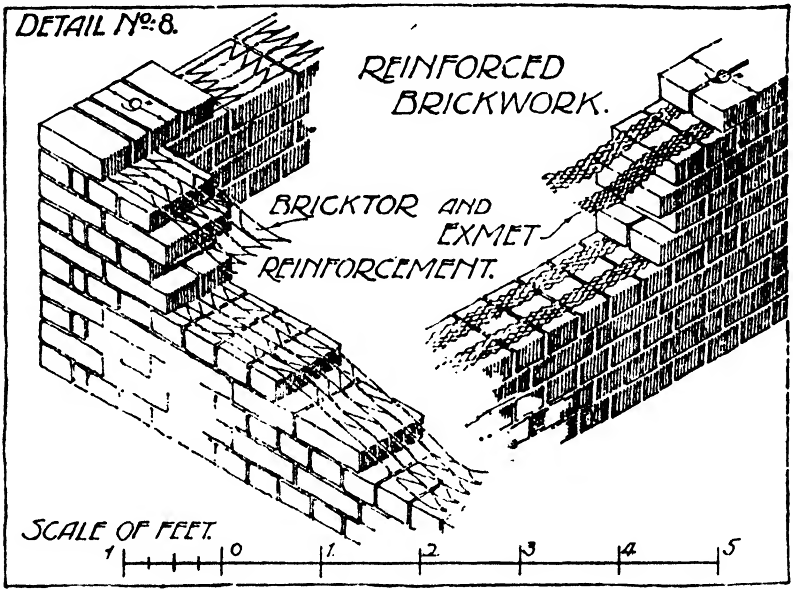
28. Hoop iron, wire mesh and other metal reinforcement. Hoop iron, in strips from 1″ to 1¼″ wide and $\frac{1}{16}$″ thick, is often used to strengthen the longitudinal bond of a wall. It also adds consider-



DETAIL No. 7.
PLANS OF A TWO BRICK WALL IN SINGLE FLEMISH BOND.

ably to the side stiffness of a thin wall. The strips are bedded in the mortar joints, and bent and hooked at quoins and return angles of the brickwork. To preserve hoop iron it may be galvanised, or preferably coated with hot tar and immediately drawn through fine, dry sand.

An example of the use of hoop iron is given in Vol. III, in which it is applied to thick walls.



Wire mesh is another type of reinforcement. Rolls of galvanised wire netting of medium strength are prepared, $2\frac{1}{2}''$ wide and upwards; these are unrolled upon the mortar joint in the centre of each half brick in thickness but often at closer intervals. Angles and junctions are lapped like hoop iron; the netting beds within the joint and does not increase its thickness.

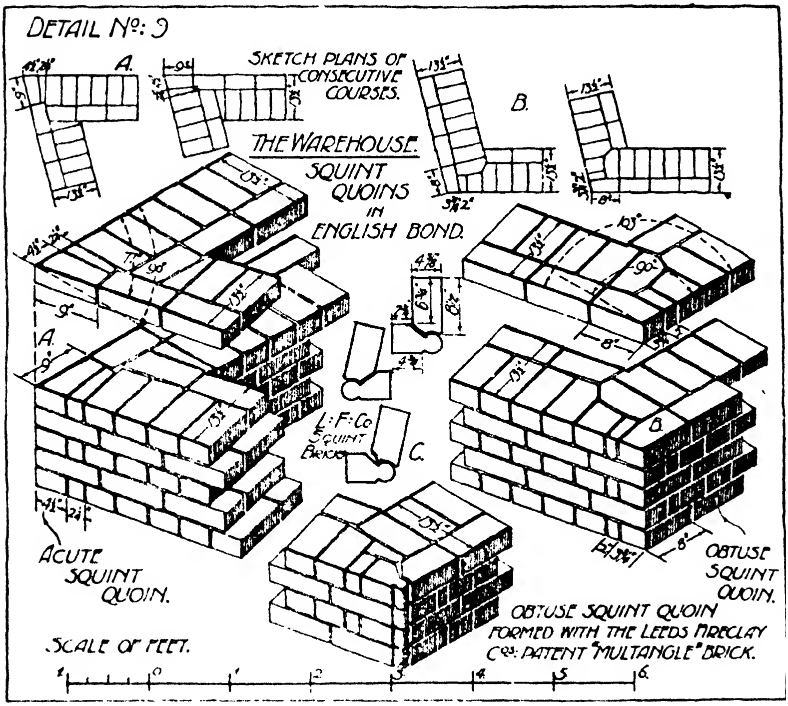
Two well known kinds of modern reinforcement are "Bricktor" and "Exmet".[1] Both are specially useful for improving the bond in thick walls, thin partition walls, boundary walls, curved wing walls built of headers, etc. Applications are shown in detail No. 8. It is evident that this kind of reinforcement besides resisting horizontal movement would help to prevent buckling under side pressure by acting like a cord in tension when stretched between two points and pressed upon sidewise.

[1] See Chapter on Materials.

Squint Quoins

When the walls of a building meet at an angle other than a right angle, the quoin is known as a "squint" quoin, and may be either acute or obtuse. Such quoins occur in the warehouse.

29. Squint quoins to warehouse. In the loading shed one wall is longer than the other, thus producing an acute-angled squint at the back street and an obtuse-angled squint at the opposite angle.



Detail No. 9 shows these angles with typical examples of the bond when standard bricks are cut to shape. In special work, where numerous quoin bricks are required to one pattern, purpose made bricks are desirable.

The principle of bonding acute angles is the same as that adopted for right-angled quoins—see Vol. I—the quoin brick and adjacent closer being splayed as in detail No. 9 at A, to avoid sharp angles and bad cutting. In all cases the stretching course passes uninterrupted to the angle, and the heading course butts against it on the splay. The skin of the brick is removed in forming the squint and

when using common brick a minimum area of cut surface should be exposed to avoid excessive absorption. Work executed in rubber bricks, though not to be recommended for such situations, would not suffer by cutting because the surface is not vitrified.

In this detail, because of the acute angle, it is possible to maintain the ordinary external face dimensions on both stretcher and header faces and to reduce the dimensions of the unseen surfaces, but at B in this detail the faces must be reduced externally to size suitable for bonding and obtainable out of an ordinary brick. In arranging the widths of the quoin header and closer, note that the sum of these must equal the length of the stretcher face of the quoin brick, less $2\frac{1}{4}''$, in order to start the bond.

In the example the angle allows an $8''$ stretcher face on the quoin after splaying the brick and making the return header joint at right angles to the splayed header face. The resulting quoin brick is thus $8''$ on stretching face, $3\frac{3}{4}''$ on header face and, as $8''-2\frac{1}{4}''=5\frac{3}{4}''$, and the header face supplies $3\frac{3}{4}''$, the closer must be $2''$ wide.

30. Multangle bricks. Specially made "multangle" bricks are shown at C in this detail; these present a large angle bead which is formed on the shorter bricks. A portion of the bead is in contact with a complementary hollow on the longer brick and the back is mitred at 45° forming normally a right-angled quoin.

By opening out the back joint of the bricks, an obtuse quoin can be formed and by cutting off the portions shown by dotted lines acute quoins can be formed within reasonable limits.

These bricks are obtainable chiefly with glazed faces but can doubtless be supplied unglazed and to suit any class of work.

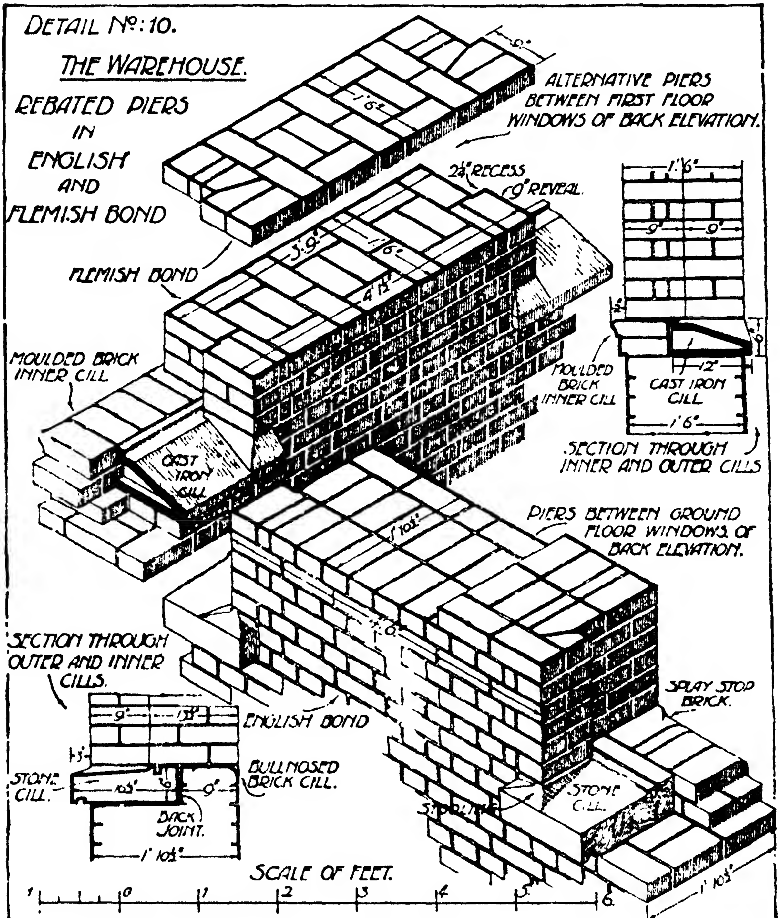
Rebated Piers in Solid Walls

31. Rebated brick pier in English bond. In the back wall of the warehouse on the ground floor the walls are $2\frac{1}{2}$ bricks thick in English bond and piers $4'\ 6''$ wide occur between the window openings; these have $9''$ reveals and $2\frac{1}{4}''$ recesses for the window frames. Such piers are known as rebated or recessed piers.

The successful bonding of the brickwork depends upon a correct selection of width and in English bond this should be a multiple of $9''$ if it is desired to avoid half bats in the stretching courses.

The pier of detail No. 10 is six bricks wide and gives perfect bonding on the face of the work, but the $2\frac{1}{4}''$ recesses make half bats necessary in the stretching courses of the internal elevation. Previous principles of bonding are adhered to and applied to the broader reveal, the latter giving a better architectural effect in large openings and being quite satisfactory in thick walls. In small openings the

deep reveal would cut off too much light, but as the smaller openings usually occur in small buildings the narrow reveal employed therewith is quite in character with the work.



32. Recessed brick pier in Flemish bond. Considering a possible application of Flemish bond to the back wall of the warehouse, correct bonding of the piers between the windows requires enunciation of the following rules which may be verified by setting out face bonds:

(*a*) The width of a *pier* must be at least 2½ bricks; if larger the increase must be 1½ bricks or some multiple of this measurement,

hence the number of bricks in width equals $2\frac{1}{2}+(n\times 1\frac{1}{2})$, where n may be any whole number. Piers thus become 1′ 10½″, 3′ 0″, 4′ 1½″, 5′ 3″, etc.

(*b*) The width of an *opening* may be $2+(n\times 1\frac{1}{2})$ bricks, which gives 1′ 6″, 2′ 7½″, 3′ 9″, 4′ 10½″, etc.

The selection of other dimensions will result in some irregularity of bonding, which may, however, be admissible in some cases.

Thus, following these rules for successful spacing the nearest width of pier for the position referred to would be 4′ 1½″, as shown in detail No. 10.

The example applied as an alternative to the first floor of the warehouse adheres to the rule and the face appearance is therefore perfect. No special difficulty occurs with the bonding, but alternative plans of this and the previous example should be set out to ensure familiarity with the arrangement.

Special Window Cills

33. Outer and inner cills to warehouse windows. The same detail shows an arrangement of window cills which has not previously been employed in the selected examples. The stone cill in this case is 16½″ × 6″ in cross section, while the inner cill is of bull-nose bricks laid flat and placed on a level with the stone cill. The bricks are laid *between* the recessed jambs to avoid disturbance of the course if appreciable settlement of the pier occurs, and a splay stop brick terminates the bull-nose angle at the jambs.

The portion of the brickwork between the cill and head of a window is not subjected to the same load as the brickwork under the piers and the settlement is consequently less; if, therefore, stone cills are bedded solidly upon the brick at the time of building the excess of pressure on the ends of the cills will often cause them to crack near the centre because the material is brittle and cannot withstand bending. The effect is similar to that described in relation to brick cills in Vol. I.

To obviate this, one method is to bed the cill hollow, that is, to lay it in mortar at the enclosed ends only, then leaving until the mortar has set and final settlement of the wall under the gradually increasing load is complete. The bed joint of the cill is then pointed up in cement mortar and may also be grouted up solid from the vertical back joint which would be left open for the purpose.

Another method is to bed the cill on loose sand, then allow settlement to occur, which compresses the sand. When finally settled the sand is raked out to a depth of 1″ or more and the joint wetted and pointed up with mortar.

A still better method is to complete the walls, omitting the

bedding of all cills until the brickwork has properly set, but providing toothings for their reception; then, working downwards from the scaffold the cills are inserted and the joints made good. The operation of inserting and bedding the ends is known as "cutting and pinning", because the work is neatly cut, the end fitted, and the bed course wedged tight at the ends with pieces of slate before pointing. "Cutting and pinning" is, however, too costly for general adoption.

34. Metal cills. The same detail illustrates a cast iron cill of very suitable form for foundries, workshops and warehouses where vibratory or sudden loads are common. The cill is $12'' \times 6''$ in external dimensions, cast hollow in $\frac{3}{4}''$ to $1''$ metal and recessed at the top surface with a weathered rebate to receive a corresponding rebated oak cill or an iron casement frame.

The inner cill in this detail is of suitably moulded brick, built in two courses, and may be carried as a dado mould across the piers between the windows, or, if preferred, returned to the face of the pier by mitred return bricks. In large buildings the dado mould would be inserted across the pier during erection and the cill portion inserted after due settlement had taken place.

Hollow or Cavity Walls

Cavity walls have already been referred to in connection with basement construction, see paragraph 17. Their use will now be considered in the general building of external walls, with applications in the construction of the house.

35. Purposes of cavity walls. Cavity walls may serve any, or all, of the following purposes:

(*a*) To ensure dryness of the interior surfaces of external walls.

(*b*) To obtain a more constant temperature in the interior of a building without increasing the quantity of material in the wall.

(*c*) To increase the stability of comparatively thin walls by broadening their section while using the same quantity of material.

(*d*) To utilise economically two kinds of brick which may vary considerably in thickness.

Each of these purposes are briefly discussed.

36. Resistance to damp. Damp may be conveyed to the interior surface of an exposed wall in two obvious ways, viz. by absorption of rain water streaming down the face and by reception of moisture from a humid atmosphere. The former is the cause of most damp walls which are open to the air, because the bricks may become saturated by direct contact with the water. Cavity walls cut off the

contact and stop transmission while they provide for the possible leakage through faulty joints by draining off, through the cavity, any water which may penetrate.

The reception of moisture from a damp atmosphere is unavoidable whatever kind of wall be employed, so long as the bricks and mortar are porous, but the effect is usually noticed only by a reduction of temperature. When cavities are well ventilated and damp atmosphere allowed to circulate freely through them this effect is noticeable.

37. Equability of temperature. Apart from the effect of damp air on the temperature of the inner portion of the wall above referred to, cavity walls do assist in preventing rapid changes of temperature if the cavity is not over ventilated. This greater constancy of internal temperature is due to the air sheath, enclosed by the cavity, being a slower conductor of heat than the brickwork, and the result is, that with the same total thickness of brickwork, the outward flow of heat from the interior is retarded in the winter and the inward flow from the sun-heated atmosphere is retarded in the summer.

If, however, too free ventilation is provided through the cavity this condition may be quite destroyed, especially in the winter time.

38. Increased stability of cavity walls. In many districts where dwellings are erected without basements or attics and thereby probably restricted to two storeys, 9″ solid walls may be built without violating the local bye-laws. Such 9″ walls are often allowed up to a height of 25 ft. above the footings, but they are not a very satisfactory construction because they are too high in relation to their thickness to produce stability, and at the same time, if built of common bricks and poor mortar, do not exclude damp.

The stability and resistance to the passage of moisture are both increased by building the wall in two 4½″ portions, each in stretching bond, with a 2½″, or larger, cavity between. For an improvement in stability the portions must be solidly bound together at frequent intervals by "bonding bricks", or "metal ties", of such form and substance as to prevent the conveyance of moisture or driving rain from the outer to the inner wall; see paragraph 42.

39. Use of facing bricks. Many cavity walls of this class are constructed with two kinds of brick, the facing bricks of a selected material and the backings of common brick. The facing may be selected for the purpose of architectural treatment, or to obtain a durable, impervious external surface. In these cases it is probable that the bricks, being of different dimensions or varying in the

thickness of mortar joints, do not rise at the same rate, and horizontal joints only coincide at intervals of several courses in height; with certain kinds of bond tie these may only be inserted where the course joints coincide in level.

40. Depth of recesses. With a $2\frac{1}{4}''$ cavity between two half brick walls, the reveal being formed by the outer portion, an inner reveal is obtained $6\frac{3}{4}''$ deep, which easily takes the thickness of a cased frame for double-hung sashes. Such a frame placed in the $4\frac{1}{2}''$ inner reveal of the $9''$ wall projects beyond the inside face and is somewhat objectionable in appearance; this arrangement was illustrated in Vol. I.

41. Disadvantages of cavity walls. While cavity walls possess many advantages, they also have the following disadvantages:

(*a*) They waste a little interior space.

(*b*) They require special treatment at door and window openings; see paragraph 45.

(*c*) In thin walls the whole of the weight from floor timbers may have to be borne by the $4\frac{1}{2}''$ inner portion.

(*d*) The cavity may harbour vermin if these can gain access, and thus produce an insanitary condition which is difficult to remedy since the cavity cannot be inspected.

42. Bond of cavity walls. The method of bonding the two portions of a cavity wall is to insert glazed bricks or metal ties, of special form, in convenient positions, the ties entering each portion of the wall to a depth of at least $2\frac{1}{4}''$ if brick ties are employed and $3''$ if metal ties are used.

The common types of bond tie are illustrated in detail No. 11; their shape prevents the passage of water from the exterior to the interior surface of the cavity. Where bricks are employed they are bevelled as shown in the alternative sketches of this detail, and are also perforated and glazed to ensure well baked material and impervious surfaces.[1]

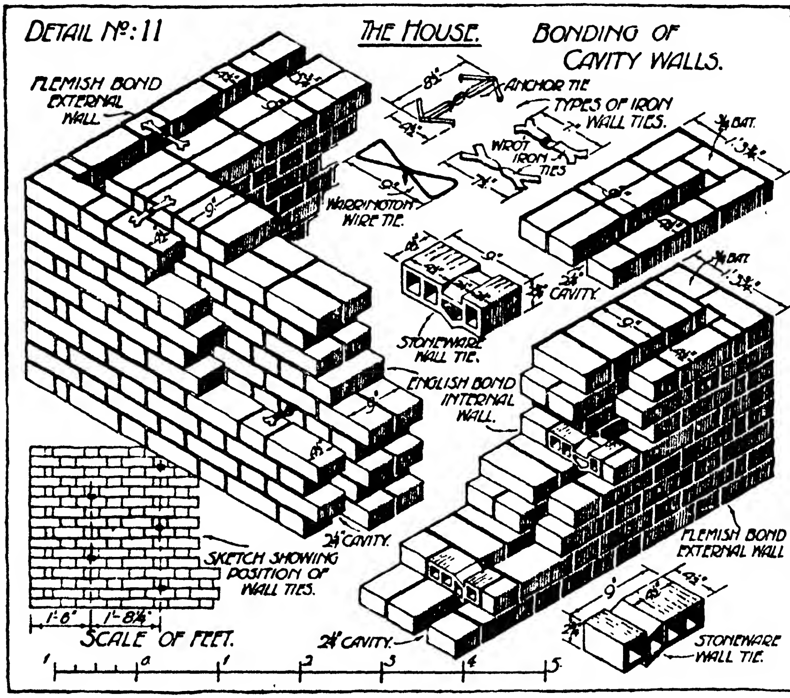
If metal ties are employed they may be of cast iron, wrought iron, or steel wire, and are twisted, depressed or otherwise so shaped where they pass the cavity, that they cause any water falling upon them to drop clear of the inner wall.

To gain a grip within the mortar joints, wire ties are dovetailed in outline, wrought iron ties are split and bent outwards, while cast iron ties have wings spreading to a dovetail form in plan. The mortar thus grips the broader ends and has to be sheared out of the joint before the tie may give way. Bonding bricks are roughened or serrated on the beds at the enclosed parts for the same purpose.

[1] See Chapter on Materials.

43. Cavity walls to the house. To transmit the loads from the heavy roof and floors to the foundations in a satisfactory manner, it is necessary to provide a 9″ inner wall, while retaining the 4½″ outer wall and the 2¼″ cavity, thus producing a total thickness of 15¾″.

Cavity walls are commonly described by giving their total thickness and the thickness of the outer wall.



From foundation to ground floor, at the basement portion, the inner wall is increased to 13½″ thick, and to provide a projecting plinth the cavity is also increased to 3¼″, hence the total thickness of this wall is 21¼″.

44. Building cavity walls. It is necessary to exercise care in building these walls in order to keep the cavity clear of mortar and brick rubbish during the progress of the work. This may be done by swathing a rod with hay or straw which is fitted closely into the cavity and thus intercepts any falling fragments. It is occasionally dragged up and cleared as the walls are raised.

45. Solid parts to cavity walls. It is advisable in all cavity walls to make certain parts solid. These include:

(*a*) Foundation walling up to the height of the basement floor, or to the ground level where no basement occurs as in detail No. 5.

(*b*) The wall immediately under the eaves of the roof, as in detail No. 14, and at No. 100, Vol. III.

(*c*) Around window and door openings, as shown in details Nos. 12, 13 and 14.

The reasons for employing solid parts are important.

Foundation walling should be solid to bind adequately the footing courses and distribute the load more uniformly over the foundation.

Eaves walling is made solid to provide a good seating for the roof timbers and to ensure some distribution of roof load over both portions of wall; to provide a solid top for workmen to move upon when erecting the roof and also to receive a damp proof course through the full thickness of the wall to prevent downward leakages from faulty slates and gutters.

Sides of openings should be solid, to protect from damp air the woodwork which is to be subsequently fixed, to prevent possible draughts of air from the cavity through faulty joints in the linings, etc., to give full support to the breadth of lintols, and in some cases to ensure sufficient solidity to take wooden plugs in the joints for securing door frames.

In these cases non-absorbent bricks should be employed such as blue bricks, pressed facings or engineering bricks laid in cement mortar. If common bricks only are available they are occasionally coated with tar on the cavity side and on the surfaces abutting against the face walling.

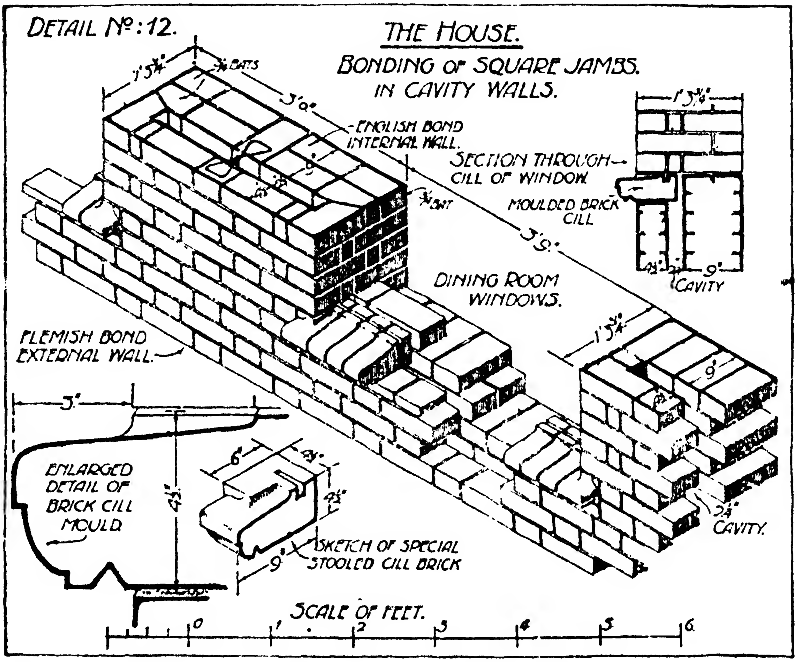
46. Bonding of quoins. Detail No. 11 illustrates the bonding of a plain quoin at an angle of the house, above the ground floor. The outer portion is 4½″ thick, built in Flemish bond instead of the commoner stretching bond which is so lacking in character. Half-headers have therefore to be employed; these are often termed "snap" headers, being broken from a whole brick and placed with the smooth header face outwards.

The inner portion of this wall is 9″ thick, built in English bond as explained in Vol. I.

Four forms of metal bond tie and two glazed stoneware wall ties are shown in this detail.

The metal ties are protected either by painting, galvanising, or dipping in a hot bituminous compound. The latter method best preserves the exposed part within the cavity, but galvanising secures the best adhesion to the mortar.

47. Square stopped ends. Detail No. 11 also shows the method of bonding a square stopped end and the termination of the cavity in a solid jamb, by using ¾ and ½ bats, together with the application of special bonding bricks to tie the inner and outer walls. Square stopped ends are applied to window openings where the frames are required to be near the face of the brickwork, in order to show a reasonable amount of constructional woodwork as a margin to the opening, in place of the meagre bead commonly revealed by a recessed jamb. At the same time more light is admitted with the

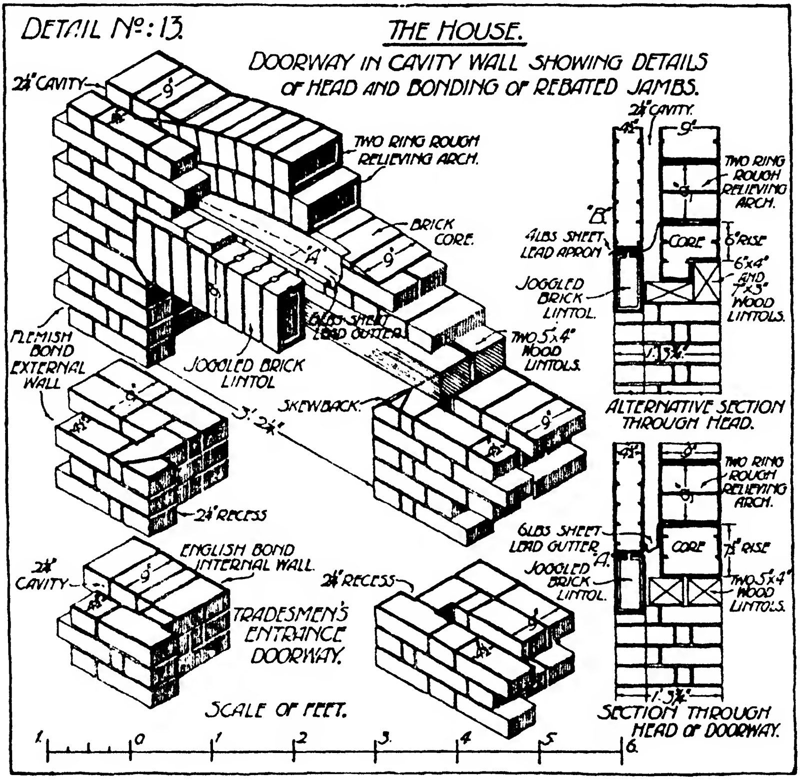


same size of frame since the internal width of the opening is maintained externally instead of being reduced to form a recessed jamb. In addition a deeper inner reveal is obtained.

48. Window openings. Detail No. 12 illustrates the construction of the dividing pier and reveals to the dining room window openings. These have plain square jambs and are intended for frames to be placed between them and not more than 3″ from the face of the wall. A 9″ moulded brick on edge cill is shown, projecting 3″ from the face of the wall and therefore overhanging the cavity 1½″. The cill bricks are set in cement and a special stooled jamb brick used to return the edge mould to the wall face.

49. Bonding brick pier in cavity wall. The bonding of the pier between the window openings is shown in this detail. The face bond is regular Flemish and the only cutting required is in the stretching courses at the solid jamb. This is due to a correct selection of the breadths of the pier and opening, which have been determined by reference to the rules given in paragraph 32.

The inner portion of the pier is an example of broken English bond.



50. Headguards to openings. As wooden frames to door and window openings cross the cavity in hollow walls, some method of preventing leakage water from dropping upon the top of the woodwork must be adopted, in order to avoid risk of decay and possible penetration of rain water to the interior. The method of doing this is to provide a saddleback gutter of 4 to 6 lbs. lead between the two portions of wall, as shown in detail No. 13 at A. The ends are shaped to discharge water clear of the wooden lintol below, and away from the inner part of the cavity wall.

Another method of guarding the head of an opening is shown at B in the same detail, where a sheet of lead is laid through the outer portion of the wall immediately upon the joggled lintol or face arch, turned up and tucked into a convenient higher course.

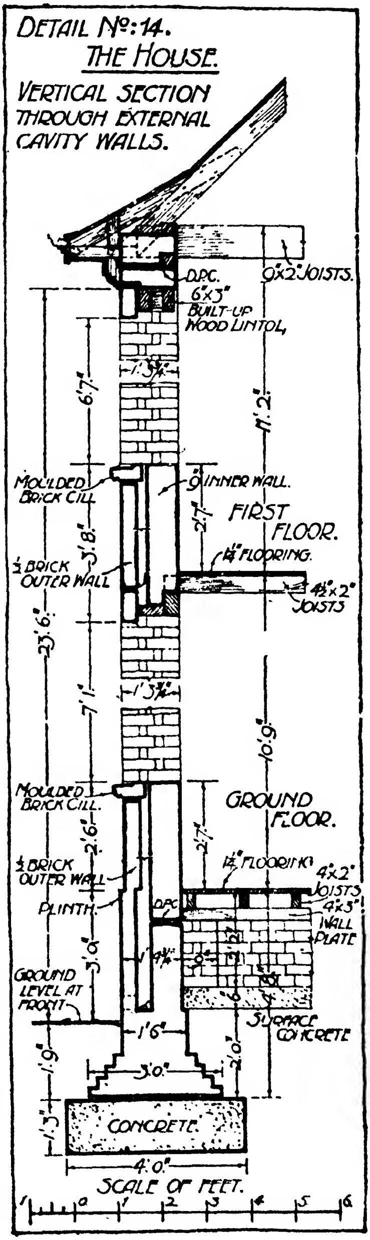
51. Head of window opening in semi-detached house. The same detail shows, in addition to the application of the lead gutter referred to in the last paragraph, a method of supporting the face brickwork over the opening by a "joggled lintol". The lintol has vertical joints and is formed by placing frog bricks upon a flat bearing piece and closing the outer joints by bedding in pure lime mortar or other fine material, and then grouting the frogs solid in neat cement poured through a channel cut across the upper rims of the bricks. The end bricks are mitred upon the upper jamb courses to provide bearing, thus producing somewhat the appearance of an arch; the mitre is necessary when the external angle is chamfered, rounded or moulded, or when the soffit of the lintol does not coincide with a course joint, as in this case. Joggled lintols derive their primary strength from the resistance of the cement to being severed vertically by the load; the force tending to cause vertical movement at any section is called *shear force*, and the resistance to shearing on a unit of area at any section is called *shear stress*. If strong enough to resist shear the lintol will then bend downwards like a beam and tend to crush at the top surface and tear asunder at the lower one; strong and rigid supports are required to prevent this, with perfectly solid filling of cement mortar at the supports and at all intermediate vertical joints.

This construction should be limited to spans of 3′ 9″ unless reinforced by threading a steel rod horizontally through the blocks, at about $\frac{1}{4}$ of the depth from the soffit, or otherwise providing some assistance to vertical support of the units. Solid grouting is a necessity in all cases.

Joggled lintols are sometimes considered to be architecturally faulty because they do not indicate capacity to provide support, but their use is justified when the woodwork of the frame is exposed, because the latter appears to assist in supporting the load. In much modern work, bricks of all kinds are successfully used in spanning openings in a similar manner to the joggled lintol. Actually, they derive their primary support from the head of a frame which is built in, but, as they are built in cement, they develop a considerable strength and when the cement is set the lintol will carry weight independently of the frame so long as the supporting brickwork remains rigid.

52. Lintol and lead gutter. The brickwork at the back of the opening is carried by two 5″ × 4″ wood lintols, relieved by a rough

arch. The lintols are broad enough to cover backing and cavity; this allows for proper fixing of the window or door frames at the head. The lead gutter prevents water dropping upon the lintol. In this case the gutter is bent and tucked into a horizontal joint in the facing brickwork at the front edge, while at the back it rises to a higher level and follows the joint of the arch soffit. If the core is filled after the arch has set, the back edge may lie upon the second course of the core.

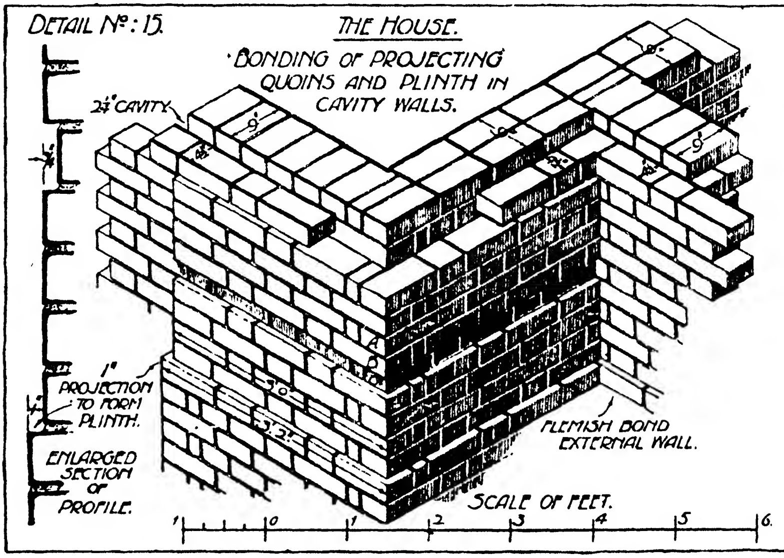


53. Front wall of the house. Attention should now be given to the complete treatment of the front wall of the house. The separate details of its construction are given to a large scale in Nos. 11, 12 and 13, but the vertical section given in detail No. 14 assembles the separate parts and shows the wall from foundation to eaves; it includes foundation, footings, cavity, positions of damp proof courses, methods of supporting floors and shows the window openings and the eaves of the roof; it also indicates brick cills, solid jambs, head guards to windows and two kinds of wood lintol available for use. The built up double lintol was described in Vol. I; the L shaped lintol is a good but uncommon form and consists of a 6" × 4" piece on edge spiked to a 7" × 3" piece laid flat. An effective support to floor joists is economically obtained by this construction.

54. Arrangement of offsets at base of cavity wall. In order to

avoid cutting the bricks in the foundation walling at the base of a cavity wall, the thickness immediately below the cavity should be made to the nearest half brick size larger than the overall thickness of the wall. The increase of thickness may be disposed on one side or on both sides of the foundation walling as may be convenient. The arrangement suitable for the chosen example is shown at the base of the section in detail No. 14.

55. Projecting quoins and plinth to cavity wall. Detail No. 15 shows the method of bonding projecting quoin courses in the front elevation of the house. The width of the cavity below the plinth we



have already seen to be 3½″, giving a projection of 1″ to the latter. At the quoins referred to, the plinth is made to project ¾″ further forward to allow for "four course quoins" with ¾″ projections to commence thereon, these being carried up in series divided by single plain courses.

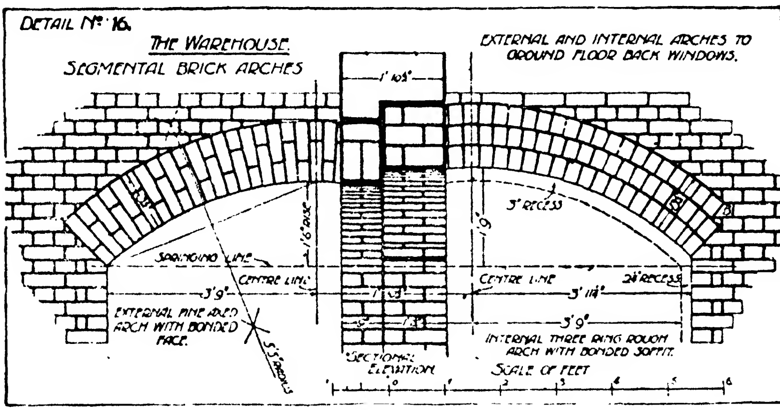
The true bond is set out upon the projecting part and the necessary reduction in dimensions made upon the recessed quoin brick to allow the perpends to be kept in the elevation. The cavity is 3″ wide behind the projecting courses at the quoin and 4″ wide behind the plinth.

As an exercise the student should draw plans of the courses marked A, B and C, setting out the principal bond on the projection and maintaining the perpends throughout.

Arches

In Vol. I the various classes of brick arch were dealt with, as defined by the kind of labour bestowed upon them, and also the flat, segmental, and semicircular forms of arch for spans up to 4 ft. Arches of larger span and of other forms will now be considered.

56. Segmental arches to ground floor of warehouse. The walls of the warehouse on the ground floor, back elevation, are 1′ 10½″ thick; the window openings are 7′ 6″ wide with 2¼″ recesses and 9″ reveals each suitably spanned by a 13½″ deep segmental arch having a rise of 1′ 6″. As this elevation is of secondary importance the voussoirs may be fine-axed to shape; this term implies carefully cut units maintaining ¼″ parallel joints and comparable with the



jointing of the surrounding wall. This arch has a 9″ soffit and would therefore be bonded on the face by alternate headers and stretchers in each course as shown by detail No. 16.

The back arch is a three ring rough arch as illustrated in half elevation in the same detail, having the soffit 3″ higher than that of the face arch.

Two new features occur in this back arch: (*a*) its soffit is 13½″ long and the voussoirs are therefore bonded lengthwise in each separate ring, producing greater efficiency in the arch for spreading and transmitting load; (*b*) the skewback is of double form as shown at B, the upper ring springing from a higher plane than the two lower ones. This latter arrangement is an advantage where the arch abuts on a narrow pier attached to a wall and when, if continued, it would meet or enter the wall if the skewback were continued in one plane. It also provides a change in appearance but causes more cutting of the surrounding work.

57. No bond between front and back arches. In this case there is no bond between front and back arches; they are separate structures kept together by the bonded wall above them which transmits part of its load to each. When two different classes of front and back arch are employed the inner one, usually a rough arch, may be the weaker if set in ordinary lime mortar, and yet the greater loads—from floor joists, etc.—bear upon this part of the structure, and it is therefore wise to use cement mortar and to see that all joints are properly flushed or otherwise filled solid.

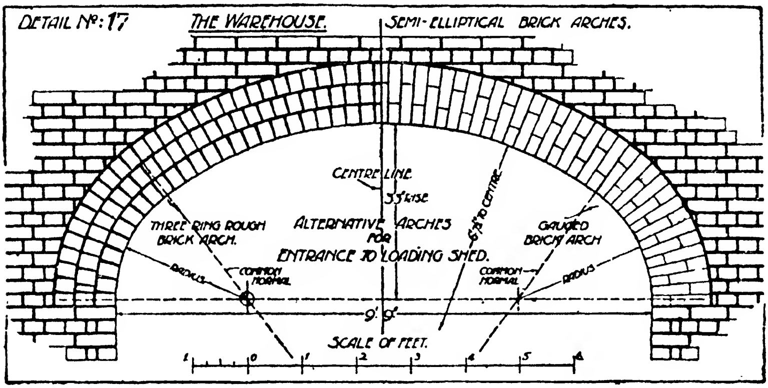
58. Semi-elliptical arches. The semi-ellipse is probably a familiar form to the student; its curve is symmetrical about a vertical axis and its rise is less than half the span, but it differs from the segmental arch in that the semi-ellipse springs normally from the springing line and gradually decreases in curvature towards the crown while the segmental arch has a constant curvature. The student should be sufficiently familiar with the methods of drawing the ellipse and with its properties, from the previous study of geometry. Semi-elliptical arches are in fairly common use, but are not worthy of adoption where the semicircular or segmental arch could be conveniently employed. While the elliptical curve in itself is beautiful, it is defective when employed with its major axis horizontal—as it must generally be in an arch—giving a sense of depression and instability and is, indeed, one of the weakest forms of arch, being peculiarly liable to distortion by lifting at the haunches. The chief objection to its use, however, is the common distortion of the correct curve either by unskilled setting out, careless workmanship in the erection, or an unwise selection of one of the many approximations to the curve composed of circular arcs.

59. Use of the semi-elliptical arch. While the general use of this arch in external work is not advocated, it must be recognised that certain positions suffering from lack of height may justify it, but when its adoption has been decided upon, an accurate semi-ellipse should be drawn with a mechanical trammel, or, a compound curve of circular arcs selected, which will closely approximate to the true ellipse. Generally the basic curve of the arch should be the soffit or intrados curve and the extrados curve should be parallel thereto. If any joinery work follows within the opening it should also be parallel. A semi-elliptical arch is more often justified over openings in internal walls.

60. Approximate ellipses. The reason for the practical adoption of approximate ellipses compounded of circular arcs, is that all voussoirs lying within the same arc of curvature may be cut to one templet or pattern, while in the true ellipse every voussoir differs in shape from the rest in one half of the arch. The choice of the exact

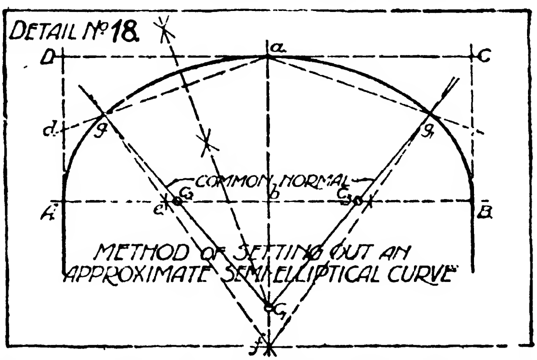
form is therefore in many cases strictly due to economy of construction and must be considered.

While many approximations or false curves are very weak in outline it is possible to make them acceptable if the ratio of rise to



span be not less than one-third, by the method illustrated in detail No. 17, which is a fairly suitable application to the loading shed entrance in the back elevation.

The method consists of locating five points in a true ellipse and causing a compound curve to pass through them. The known points



on the desired curve are: the ends of the major axis or springing line and the end of the minor axis or crown. Two intermediate points are also required and these are easily determined by the radial method of constructing an ellipse. Referring to the detail No. 18 proceed as follows:

Enclose the intrados of the arch in a rectangle as *ABCD* and draw the centre line *ab* produced below the springing. Divide *AD* and *Ab* into two equal parts at *d* and *e*, and make *bf* equal to *ab*; join *da* and *fe*, producing the latter

upwards to intersect da at g; g is a point on a true ellipse. Bisect ag and produce downwards to cut af at c_1; join c_1 to g, cutting Ab at c_2. Then $Ac_2 = gc_2$ and $gc_1 = ac_1$. Find similar points to g and c_2 on the opposite half of the diagram either by projection and measurement or by repeating the construction.

Then c_1 is the centre for a circular arc passing through gag_1 and c_2, c_3 are centres for arcs continuing the curve to the springing points A and B. Having thus settled the centres of curvature for the intrados curve they are used for all parallel curves either within the opening or outside it. The extrados is therefore drawn parallel and at the required depth of arch which is set out past the opening upon the springing line. The arcs of the extrados or other parallel curves will join upon the common normals c_1g and c_1g_1 continued.

61. Axed and gauged arches of semi-elliptical outline. When either axed or gauged arches are constructed of the approximate form of detail No. 17 a bed joint should be arranged at the junction line of the compound arcs, viz. c_1g and c_1g_1. The centre sector of the arch between these lines is then divided into an odd number of voussoirs not greater than the thickness of a brick and set out upon the extrados. The lower sector is similarly treated, but not necessarily into an odd number of voussoirs. All the bricks in one sector are alike because their joints radiate from the same centre, hence two templets serve for the whole arch, one serving for the two lower sectors and the other for the middle sector.

Whatever curve is adopted, whether a true semi-ellipse or an approximation, the face joints should be arranged as normals to the intrados, viz. at right angles to a tangent to the curve at the selected position of the joint. For architectural appearance and for truthful construction it is not admissible to radiate the face joints from the centre of the springing line as is so often done.

Both gauged and axed arches should be bonded on the face and soffit if more than 4½″ long and more than 9″ on face.

On one half of detail No. 17 a three ring rough arch is shown as an alternative to the gauged arch.

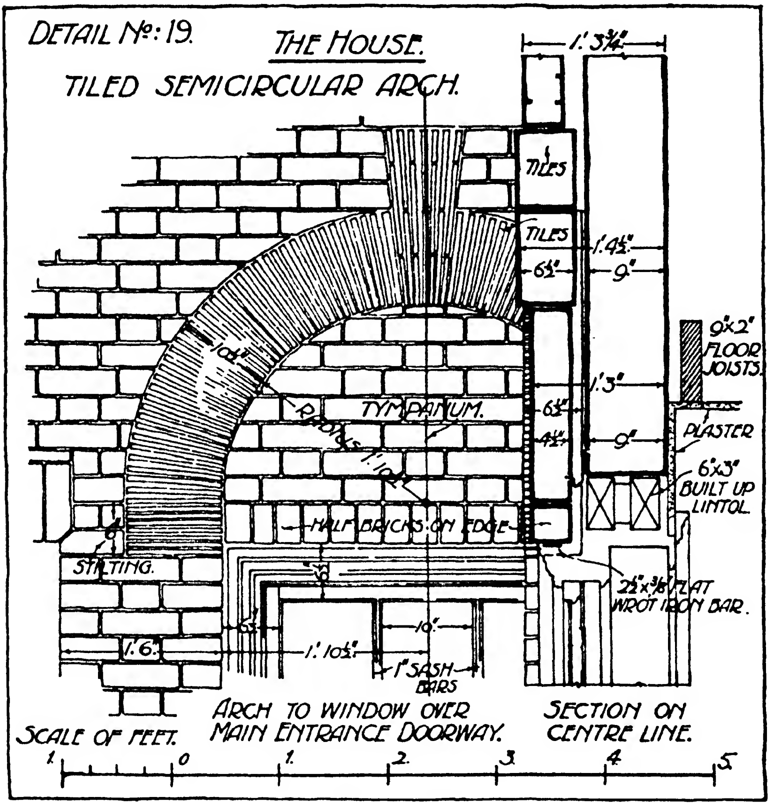
These arches, whether gauged, axed or rough ring, provide good drawing practice. The two latter might be employed as alternatives to span the opening between the loading shed and the main building and students are recommended to prepare complete details of these to a large scale.

The centers for the segmental arches are given in paragraphs 303 to 309 and for the elliptical arches in Vol. III.

62. Tile arches. In some modern work arches have been constructed of plain tiles, which, like other units, may be set normally round any curve upon a center and bedded solidly in cement mortar; see detail No. 19. If the tiles have rough surfaces, *e.g.* sand faced or rustic tiles,[1] good lime mortar may be satisfactorily employed. Specially thick tiles are the most suitable for arches.

[1] See Chapter on Materials.

One difficulty arises in setting tile arches, viz. to avoid discoloration of the bottom and face edges of the tiles by the cement, which is often grouted into the joints. A good method of procedure is to provide a closely-lagged center with the laggings projecting about 2″ on each side, lay ½″ of sand upon it as the building of the arch proceeds, bed the tiles in cement mortar over the greater part



of each bed but leaving the edges clear; as each tile is laid its soffit edge is worked down into the sand which prevents the cement squeezing out beyond the edge of the tiles. If grouting is to be done the beds are left hollow, a margin of mortar being spread upon the tile but clear of the edges as before, and the hollow joints are grouted solid soon after the arch is turned. After setting, the center is removed and all sand brushed clear of the joints; the tile edges and joints are then wetted to prevent too rapid absorption of moisture

from the pointing mortar and the joints are pointed in cement and sand in equal parts, kept stiffly plastic; before setting, the joints are finished with a rounded jointing iron, thus producing recessed joints and distinct outlines of the exposed tile edges.

Tile arches may be laid in a single ring $6\frac{1}{2}''$ or $10\frac{1}{2}''$ deep, giving $10\frac{1}{2}''$ or $6\frac{1}{2}''$ soffits respectively if ordinary plain tiles are used. They are suitable for arches having a radius of 1′ 9″ or more but are not advisable for quicker curvatures. The tile arch corresponds to a rough arch in brickwork and has wedge shaped joints; for this reason the rougher tiles key best and resist distortion if heavily loaded.

When the arch has a depth of $10\frac{1}{2}''$, the curvature of the tiles shows on the face and the concave surface should be kept downwards while working symmetrically from each abutment.

Specially large keys may be formed of a group of tiles bonded together like bricks as shown in detail No. 19, where the arch is applied to a first floor landing window of the house.

In this example the tympanum of the arch is filled with ordinary brickwork $4\frac{1}{2}''$ thick in Flemish bond and supported upon a course of bricks on edge erected upon a $2\frac{1}{2}'' \times \frac{3}{8}''$ bearing bar and solidly bedded and flushed in cement mortar.

CHAPTER THREE

FIREPLACE AND CHIMNEY CONSTRUCTION

In Vol. I elementary matters in connection with the construction of flues and fireplaces were considered, and the terms in common use were defined. The illustrations and description included the foundations, breast walling, ground and first floor fireplaces and hearths and the simple turning of flues.

It is now necessary to state the regulations most generally adopted to govern the construction of flues and fireplaces. These are contained in local bye-laws which may vary slightly in different districts, but are based upon the Model Bye-laws of the Local Government Board.

63. Local Government Board Bye-laws. The object of the section of these bye-laws[1] to which we refer is to ensure durable and safe construction of fireplaces, flues and stacks and their immediate surroundings and to prevent accidental combustion of woodwork which may be in proximity thereto. The provisions of these bye-laws to meet our present purpose are here summarised, but the student should, at the same time, make himself familiar with the local bye-laws for his own district.

Materials of construction. The materials employed must be incombustible, durable under large changes of temperatures and soundly put together.

Brickwork in good mortar meets these requirements.

Foundations. Foundations starting from the ground level must be on solid earth with concrete and footings similar to those of the adjoining walls.

Jambs. Jambs to the sides of fireplace openings may project to any required distance but must be *at least* 9″ *wide*, and, if the projection be more than 4½″ and the width less than 13½″, the jambs must be tied by a caulked chimney bar of wrought iron (or steel) where an arch is employed to support the breast walling above.

Thickness of flue walls. The brickwork surrounding a flue, in jambs, breasts and stack, must be at least 4½″ thick.

Hearth. The hearth in *front* of an opening must be 6″ longer than the opening on each side of the fireplace and project 18″ from the face of the jambs; the hearth must also be at least 7″ thick and of incombustible material.

[1] **Local Government Board Model Bye-laws for "Streets and Buildings".**

Chimney backs. In dwellings, the back of the fireplace opening for a *kitchen range* must be 9″ thick if in a party wall and continued at this thickness for a height of at least 6 ft. above the opening. All other fireplace openings in party walls must have 9″ backs continued to a height of at least 1 ft. above the opening.

In external walls backs must be at least 4½″ thick.

Chimney stacks. Chimney stacks must be constructed of at least 4½″ external walls and be carried to a minimum height of 3 ft. above the highest point of intersection with any part of the roof.

For structural safety no stack may be carried to a greater height than six times its least breadth measured at the highest point of its emergence from the roof, unless strengthened and made secure.

Size of flues. While some local authorities require dwelling house flues to be at least 14″ (13½″) × 9″, this size of flue is not specifically mentioned in the Model Bye-laws. The adoption of the above size is due to a provision in the Act for the Regulation of Chimney Sweepers and Chimneys, 1840, but is not now generally adhered to, 9″ × 9″ flues being common; see paragraph 72.

Woodwork in proximity to flues and fireplaces. To prevent the spread of fire to surrounding structural work the following provisions are made:

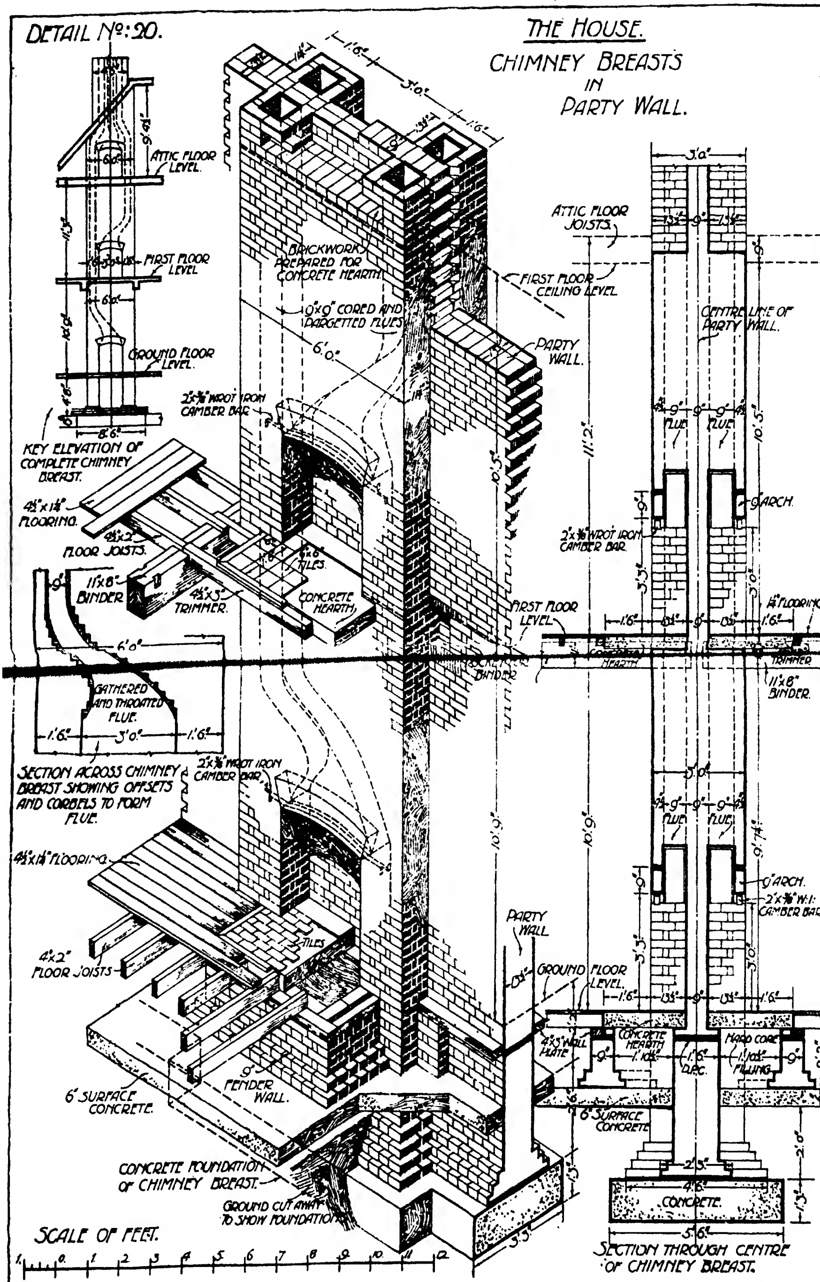
Timber built into walls. Timber may not be *built into* walls or breasts, nor wooden plugs driven into the joints for fixing purposes *nearer than* 9″ *to the inside wall* of any flue or fireplace. Metal fastenings such as nails, screws and holdfasts used to secure woodwork, etc., may not be driven nearer than 2″ to the inside wall of a flue or fireplace.

Timber near walls. If the flue walls are less than 9″ thick—and they are commonly 4½″—woodwork must not be placed nearer than 2″ to the face of the brickwork surrounding the flue or fireplace unless properly rendered with (at least ½″) of good mortar.

Timber under hearths. Timber must not be *built into* the brickwork under any chimney opening nearer than 15″ from the surface of the *back hearth.*

Pargetting. All flues must be pargetted, viz. rendered inside with lime or cement mortar as the flues are built, unless lined with square or cylindrical fireclay tubes.

External rendering. Breast walling should always be rendered with lime or cement mortar if the walls are less than 9″ thick. As seen above, this is compulsory where wooden flooring, skirtings and picture moulds are employed. Grounds may not be used on the face of 4½″ walls behind skirtings and moulds nor wood plugs employed to secure the woodwork except 9″ clear of the inside of the flue. In common practice this section of the bye-laws is often broken, but judicious placing of plugs for picture moulds may prevent this



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and skirtings may be fixed to breeze bricks in the breast walling, or the return pieces at the angles of the breast may be worked in plaster.

64. Theoretical principles of flue construction. When air is heated it expands and increases in volume, with a consequent reduction in density. Heated air therefore rises, and the colder and denser air around it falls and takes its place.

The air in the vicinity of a fire becomes hot and ascends, taking the most convenient upward passage, viz. the flue constructed to receive it. It is partially denuded of its oxygen in the process of combustion, but becomes charged with gaseous products. As the air in the flue does not readily cool, once the flue has become heated a considerable velocity of ascent is developed and maintained, but this varies with the initial temperature, the height of the heated column (length of flue) and the artificial restrictions imposed by the section and contour of the channel, and by the form of inlet and outlet. To obtain a good draught the inlet should be free and unrestricted without admitting cold air due to excessive size; the flue should be as straight as possible, only the necessary bends being introduced and these free from abrupt turns; the outlet so situated as to avoid eddies and down draughts due to the effect of surrounding structures and roof surfaces. A slight restriction of area at the outlet may increase the velocity of exit and improve the efficiency, provided that an easy change of section is employed.

65. Grouping of flues. As suggested in Vol. I, flues are grouped for the purpose of economy in construction and also to increase their efficiency. Some flues in a dwelling are in fairly constant use, while others are infrequently used; the latter, if isolated, become damp and cold in the winter time so that if suddenly called into use the heated air and smoke are rapidly chilled in their ascent and only reach the normal velocity when the flue has become warm and dry. Grouping is therefore an advantage, because heat is conducted through the brickwork in sufficient measure to prevent a very low temperature being attained in the unused flues.

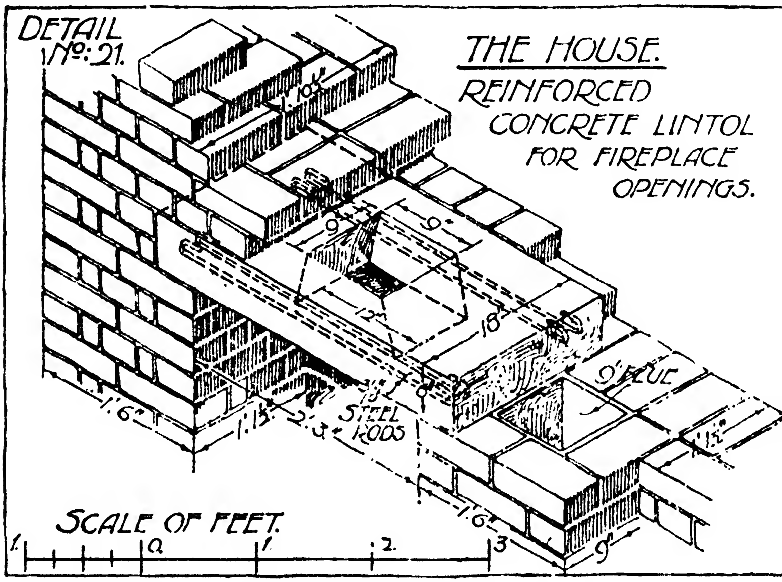
While it is important to group flues for the above reason, it is often equally important to do this in order to obtain architectural effect. Stacks to isolated flues are necessarily small and consequently lose much of their value, but by grouping, larger stacks and more picturesque effects may be obtained.

There are certain types of buildings in which it may be an architectural advantage to subordinate the chimney stacks, in which case they may still be grouped for economical reasons but placed in such positions as to be practically unseen.

Construction of back to back Fireplaces

The example of construction given in Vol. I consisted of part of a series of fireplaces and flues in an external wall. The construction will now be studied of two 3-tier fireplaces and flues placed back to back in a party wall with the flues grouped into one stack.

66. Fireplaces and flues to the house. In the selected example there are two tiers of fireplaces to each house, placed back to back in the 13½″ party wall. Regulations require the back of a fireplace opening to be 9″ thick, which may be diminished to 4½″ at certain



heights above the opening according to the type of range employed. In this case we have maintained a 9″ back to flues and fireplaces from the ground floor level to a point below the roof line, where the back is reduced to 4½″, the flues being gathered inwards 2¼″ at each side and then merged into a six-flue chimney stack with 4½″ withs and 9″ external walls. Detail No. 20 illustrates this arrangement. A small, inset elevation shows the disposition and dimensions of the fireplace openings, the floor levels, the turning and gathering of flues and the stack grouping, while fuller details of the latter are also given.

Brick arches are not exclusively used to support the breast walling over a fireplace opening. In some districts stone lintols are employed, while in others pre-cast concrete is adopted. A good method

is to employ a perforated pre-cast reinforced concrete lintol as shown in detail No. 21, since there is no thrust on the jambs as in the case of arched construction and tension is taken by the steel rods.

67. Breast walling and foundations. The construction commences with the solid foundation which is at the same level as that of the adjoining walls, and projects in courses of footings appropriate to the width of the jambs immediately borne thereon. In addition, the concrete projects 6″ all round the base.

In this example the fireplace openings are of uniform width, viz. 3 ft., and it is convenient to maintain a constant breadth of breast, 6 ft. wide, until reduced to the stack width at the roof line.

68. Bonding of jambs, breasts and flues. English bond is adopted for the jambs and solid breast walling, and stretching bond for the 4½″ flue walls. The bonding shown in detail No. 20 is used for the chimney back, party and flue walls near the level of the attic floor and the bond at other parts of the breasts may be traced in a measure by the vertical joints on the face of the brickwork.

Students should isolate some of the courses where changes of section occur and work out the bond in detail. The following exercises in bonding are suggested:

(*a*) Two courses below the sleeper plate of the fender wall round the ground floor hearth.

(*b*) The bonding of jambs to chimney back and party walls a little above the ground floor level.

(*c*) Similar to (*b*) but the position above the first floor.

Sketching bonds on squared paper is a useful variation on the accurately scaled drawing, and also assists greatly in primarily solving problems of bond where it is intended later to prepare a finished scale drawing.

69. Chimney stack. The bonding of a chimney stack depends upon the thickness of the walls. If 4½″ external walls are employed, stretching bond—often called chimney bond—is most common, though Flemish bond may be economically used. In the detailed example the external walls are 9″ thick, and in detail No. 22 are plans of alternate courses in English bond, and also an alternative in Flemish bond for 4½″ external walls.

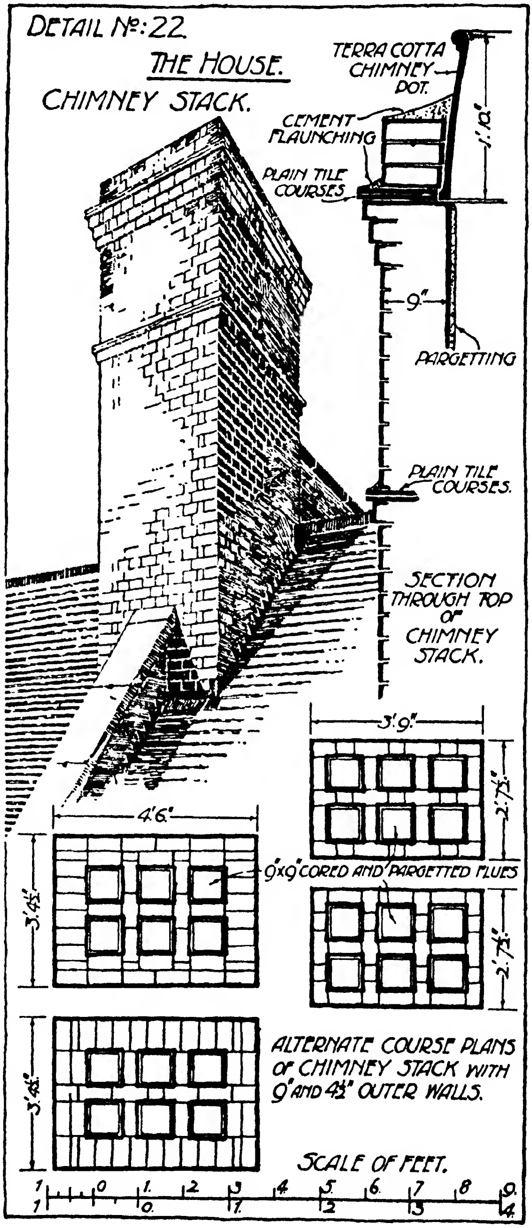
Examination of this detail will show that Flemish bond is peculiarly suited to stack bonding with 4½″ walls because the alternating headers and stretchers coincide in measurement with the breadths of withs and flues.

Withs should be well tied at each cross junction by alternate stretchers and to the external walls by alternate entry of the courses to a distance of at least 2¼″. An alternative method is to employ mitre bricks or bevelled bats, but whatever method of bonding is adopted the important point is to make all withs as airtight as possible by adequate bond and efficient bedding in mortar; rendering

will then add to the probability of obtaining airtight walls. If defects occur in the withs, one flue will draw air from another, and if the leakage is from a cold to a warm flue, the velocity of the ascending current will be reduced and a tendency towards down draught occur. Enclosing walls must be equally airtight to prevent escape by any but legitimate outlets and external walls must be particularly sound because the coldest air would be admitted through any defects in them.

Stack walls are advantageously 9″ thick because they more efficiently protect the flue outlets from damp and from loss of heat by conduction.

Perspective detail No. 22 shows the architectural treatment of the stack and its surroundings, and the enlarged vertical section illustrates the head of the cement rendered



brick flue, the shape and mode of fixing the fireclay terminal, together with brick oversailing courses; the latter have a tile covering and are surmounted by a brick blocking course.

It should be noticed that the oversailing courses forming the architectural features of this stack are of small projection. The common method of arranging these courses in steps of 2¼″ tends to produce a heavy and unsatisfactory appearance and greater refinement is obtainable by limiting such rectangular projections to not more than 1″, unless a properly moulded cornice is adopted.

70. Tile cornice coverings. Tile courses are very useful in protecting projections which have many vertical joints, as explained in Vol. I. In this case, double courses of ordinary flat roofing tiles, 10½″ × 6½″, have been employed, laid with broken joints in plan, bedded solidly and weathered in cement mortar. The tiles project about ¾″ over the brick cornice and enter 6″ or more into the wall, forming a rebate for the flanged base of the terminal to enter.

71. Chimney terminal and blocking courses. The chimney pot or terminal is generally a fireclay or terra-cotta shell, ¾″ to ⅞″ thick, having a square base 9″ inside diameter, and obtainable in many designs some of which have the declared object of increasing the velocity of the up current. The base of the terminal is wide enough to stand upon the brickwork and within the inner rim of the tile courses and is secured by building the blocking courses round it as closely as convenient, and making the work solid and weatherproof by grouting the joints with cement and steeply weathering the upper surface in cement mortar, see detail No. 22. This latter provision is called "flaunching", and in some cases of economical building is depended upon largely for holding the terminal in position, the base being sunk only one course within the blocking. Such fixing is weak and dangerous.

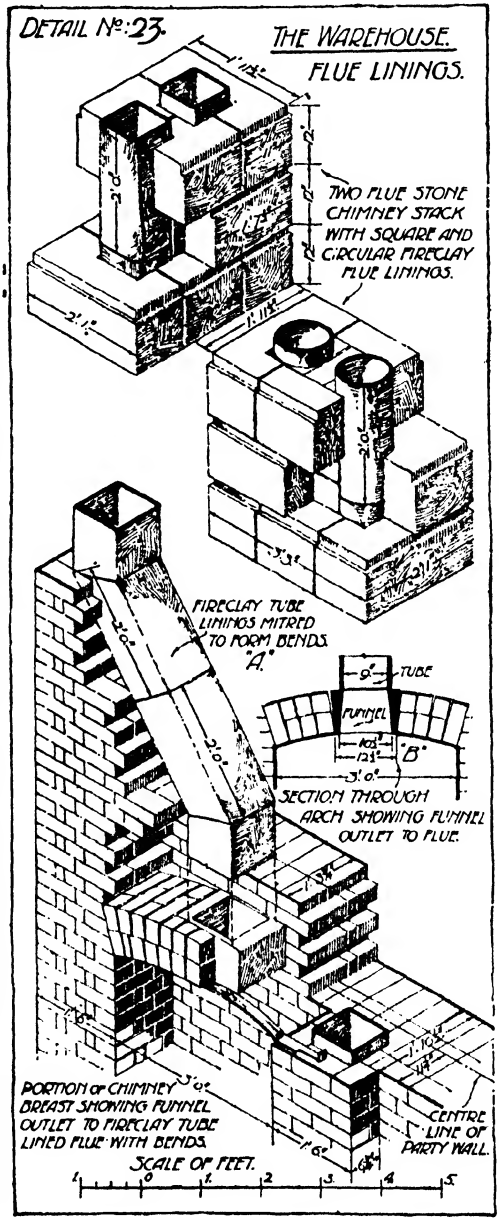
Chimney pots should not be unduly obtrusive, although they may, in certain types of design, be used to give a distinctive character to the building. Their object should not be to add to the height of a flue—except in special cases—but to increase the velocity of ascent of the smoke, by reducing the sectional area of the outlet. They also reduce the effect of down blow because of the less area acted upon.

72. Flue linings. Instead of rendering flues with cement mortar or pargetting with compounds of lime, etc. as described in Vol. I, an alternative method is largely employed in modern buildings and is particularly suitable for application in districts where the walls are chiefly of rubble stone, which is difficult to build to a fair surface in flues, etc. Fireclay flue linings having a round or square

section are therefore employed, as illustrated by the warehouse detail, No. 23; they are about 9" *external* diameter by 2 ft. long. Lined flues are also employed with brickwork and always have the advantage of being easy to sweep clear of soot.

The material employed is a fireclay which bakes to a somewhat porous condition with a slightly vitrified face caused by the intense heat of the kiln. Highly glazed linings are a disadvantage causing constant small falls of soot because it will not adhere. The vitrified face of the average flue lining will prevent large accumulations while not causing constant falls and consequent annoyance.

Linings should be built into the stonework or brickwork with neatly flushed end joints made and solidly backed with mortar, to prevent disturbance due to changes of temperature.



73. Bends in lined flues. Where bends occur, special pipes may be employed, but this is unusual, the gather-

ings being more generally formed by straight line inclinations mitred to the straight lengths of pipe at the change in direction, as indicated at A in this detail.

Another alternative is to utilise similar straight lengths of flue lining and to form the changes of direction in brickwork or stone neatly rendered in cement to a fair curve agreeing in section with the fireclay tubes.

Note. A flue should have as large an inclination to the horizontal as possible and in no case less than 40°.

74. Entrances to flues. Where the fireplace opening is supported by an arch and a single flue fire is to be used, the flue entrance would be more efficient if consisting of an opening directly over the fire and very little—if any—larger than the section of the flue. This can be provided by making the depth of the arch soffit equal to the depth of the fireplace recess and inserting in the centre a funnel-shaped fireclay or terra-cotta block with the bottom edges of the opening rounded; see detail No. 23 at B.

In detail No. 20 the ordinary method of constructing the gathering and throating of the flues is shown. The flue entrance is gradually reduced in width and at the same time gathered to one side by a series of offsets and corbellings which are illustrated in section; the fair curve is obtained in the process of rendering or pargetting by filling the spandril angles with mortar.

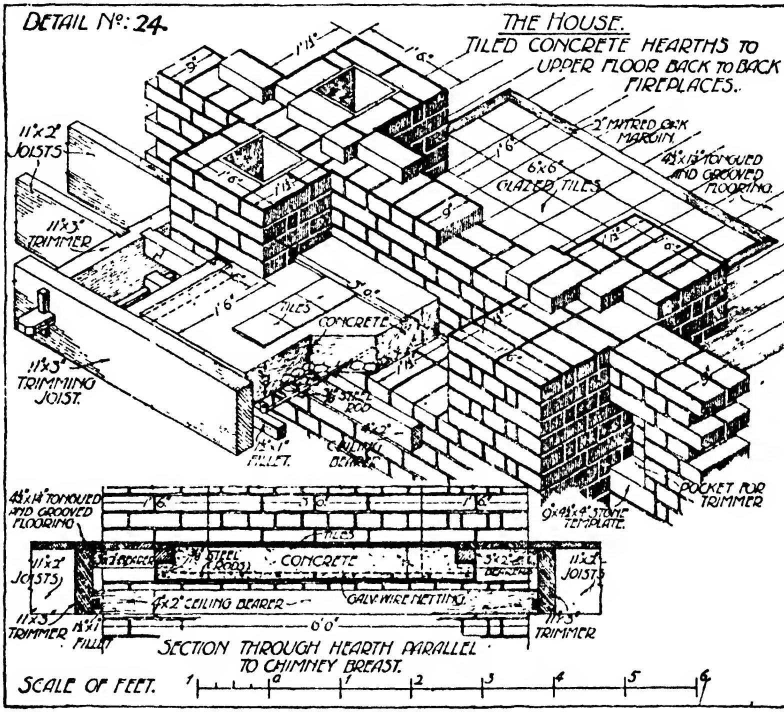
75. Stone-lined flues. In some stone districts, although brickwork may be employed for party walls and chimney construction, the flues are generally "turned" in stone. The inclined part of the flue is formed by walling 2″ stone slabs into the breasts. These show on the face of the brickwork within the room and break up the bond of the breast walling, but on the other hand avoid corbelling and offsetting to obtain the slope as required in the ordinary brick flues in which the angles at corbels and steps have to be filled with mortar in rendering the flues, which often contracts with the heat and falls away.

Stone slabs give a fairly smooth interior, and if the lengths of the slabs are selected and cut to coincide at the end joints with those of the brick or stone courses, strips of hoop iron may be placed in these joints across the full breadth of the breasts to remedy the broken bond.

76. Hearths and supports. In Vol. I there were illustrated and explained the older and probably more common methods of supporting upper floor hearths, viz. the trimmer arch with its crown against the wood trimmer, and stone slabs walled into the breasts and jambs or supported on fillets of wood nailed to the trimming timbers 4″ to 6″ below the floor surface. Further methods are given in details Nos. 24 and 25.

Concrete hearths. Detail No. 24 shows a concrete hearth slab reinforced with steel rods. Hearths of this type for upper floors may be prepared in two ways:

(*a*) The slab may be cast to the correct shape and size, about 6″ thick, with ½″ steel rods at 6″ centres near the bottom surface and left to harden. When required it is placed in position and supported



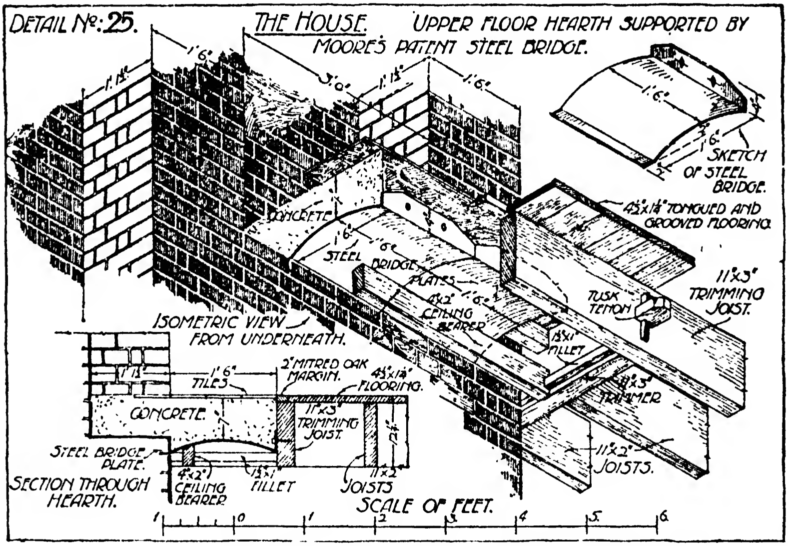
at the back upon corbel courses at the jambs and upon solid breast walling within the recess, while the front edge rests upon a fillet of wood or a light steel angle secured to the trimmer.

(*b*) The concrete may be cast *in situ* by providing a temporary shuttering of boards and bearers on which the concrete is deposited and supported until set, fillets and corbels being employed for permanent support as before; or, light iron rods covered by a close wire netting or expanded metal may be used to receive the concrete, forming a permanent centering and reinforcement to the slab.

Detail No. 24 illustrates the latter method; ⅜″ diameter steel rods are placed across the hearth at 6″ centres, one end resting 4½″ on the brickwork, and the other nailed through an eyelet bent at

right angles to the rod. Galvanised wire netting of small mesh is laid upon these, concrete with a sufficiently large aggregate deposited thereon, and when nearly set floated to the level of the tiling surface with cement mortar.

77. Steel hearth supports. Detail No. 25 shows a modern method of supporting a hearth by inserting two or more arched steel plates having a horizontal wing on one edge to build into the breast and a vertical wing at the other for screwing to the trimmer. These are known as Moore's patent steel bridge plates, and are made in 18″



lengths for hearths 18″ wide. The detail shows the soffit of the hearth in isometric projection viewed from below and also the method of supporting the ceiling bearers.

78. Woodwork round hearths. While studying details Nos. 24 and 25 the student should note the trimming of the joists across the hearth and around the chimney breasts, and also the fixing of floor and ceiling bearers at the ends of the hearth to avoid entering the wall for support. Instead of the cradling used in the fireplace detail of Vol. I, which is cut to fit the back of the arch, detail No. 24 shows a 3″ × 2″ flat bearer resting upon the concrete. This receives the hearth margin, while the short trimmer, marked A in sketch, supports the ends of the flooring boards. The same method will apply to detail No. 25.

Timber entering party walls and at the backs of flues is dealt with in connection with floor construction.

CHAPTER FOUR

MASONRY—STAIRS

In Vol. I the construction of stairs was considered but only as applied to the cottage and executed in timber. The common terms were there described and these apply to all stairs whatever material is employed in their construction.

79. Design of stairs. The position of a staircase and the design of the stairs are matters of importance in every building of more than one storey in height. This importance is best realised by personal study of good examples which may be found in all classes of buildings dating from the Renaissance of the sixteenth century, and careful measured sketches with subsequently prepared drawings will assist the student in his appreciation of the possibilities and limitations of staircase design.

For the successful arrangement of stairs and staircases the following points must receive attention:

(*a*) The stairs must be conveniently placed to allow access to all parts of the structure and a central position which will eliminate or limit the possible lengths of corridors seems most desirable.

(*b*) The staircase must be adequately lighted and ventilated from an external wall. Light is more needed in this part of the building than elsewhere because it is the most dangerous portion of the structure and yet in many buildings the stairs are placed in positions which cannot be properly lighted.

(*c*) The ascent of the stairs must be easy and regular with adequate and unobstructed head-room and of sound and rigid construction. As a general rule it is wise to limit the number of steps in a flight to 8 or 9 risers but in certain circumstances flights may consist of 11 or 12 risers, while in some less important positions long unbroken flights are unavoidable.

(*d*) The staircase should allow such a disposition of its parts as to produce a satisfactory architectural treatment because it is usually the first feature open to view on entering and may therefore be employed to give character to the whole building.

80. Types of stair. The arrangement of the steps in all stairs may be classified in four divisions, viz.:

1. Straight flight stair, unbroken, or with intermediate landings.
2. Rectangular open well stair.
3. Dog-legged stair.
4. Circular stair.

Nos. 1, 2 and 3 only are illustrated in the line diagram, detail No. 26.

81. Straight flight stair. The most obvious use of the straight flight stair is to form an approach to an entrance, porch, or portico and in this position when carried out in suitable materials it provides an opportunity for special architectural treatment. In a subsequent detail this principle is shown applied to the main entrance steps of the house, but in Vol. I the same type of stair was shown constructed in wood, in which material it is usually relegated to much less important positions.

82. Open well stair. An open well stair consists of two or more flights of steps, so arranged in plan that a clear space, called a "well," occurs between the outer ends of the steps, the space being clear for the full height between the floors with which the stair communicates, or even continued through more than one storey.

This stair requires more space than other types and is capable of very much variation in arrangement. Its flights may be parallel to each other in plan, or may be ranged round a square or rectangular well, and it particularly lends itself to architectural expression.

83. Dog-legged stair. A dog-legged stair consists of two or more straight flights of steps giving access from one floor to another arranged parallel to each other in plan, with their inner ends vertically over each other. There is no "well" between the flights. In the simplest form of the stair a level landing is placed across the two flights at the change of direction, or turn, as shown at A, detail No. 26.

84. Materials used in construction. Stairs may be constructed of wood, stone, concrete or iron, and the choice of material generally depends upon one or more of the following conditions:

(*a*) The measure of fire resistance required.

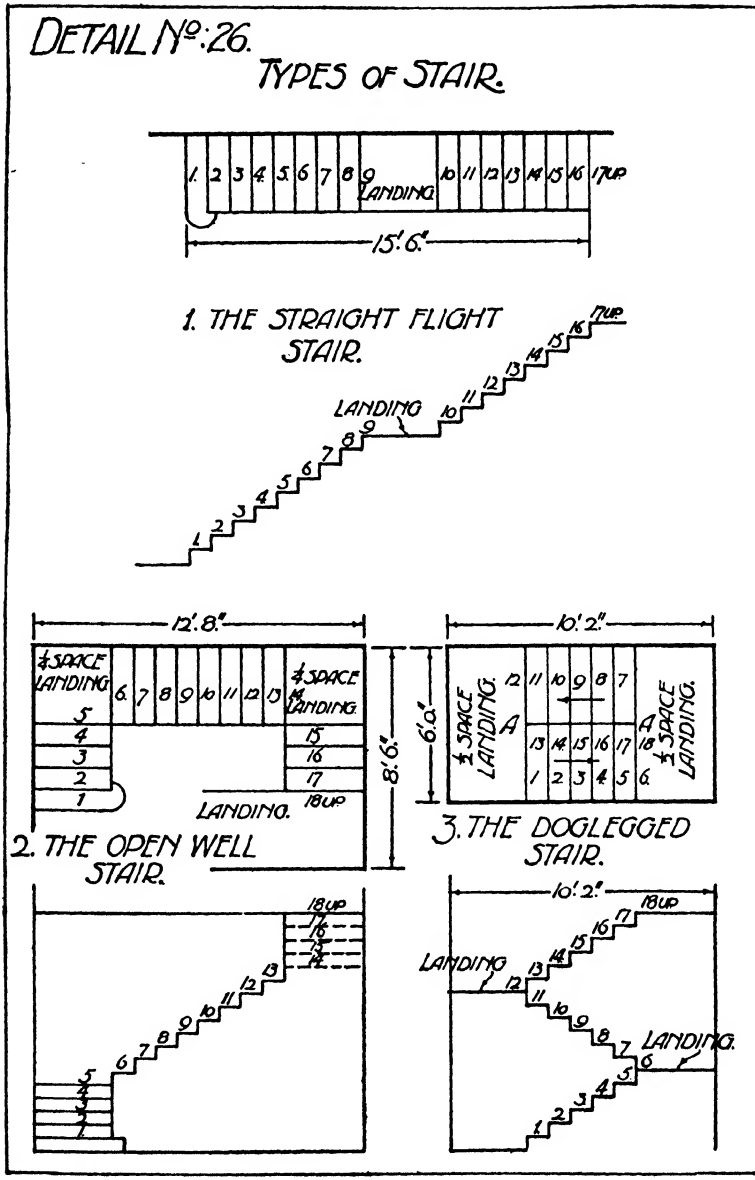
(*b*) The durability of the material for the conditions of its employment.

(*c*) Safety in use.

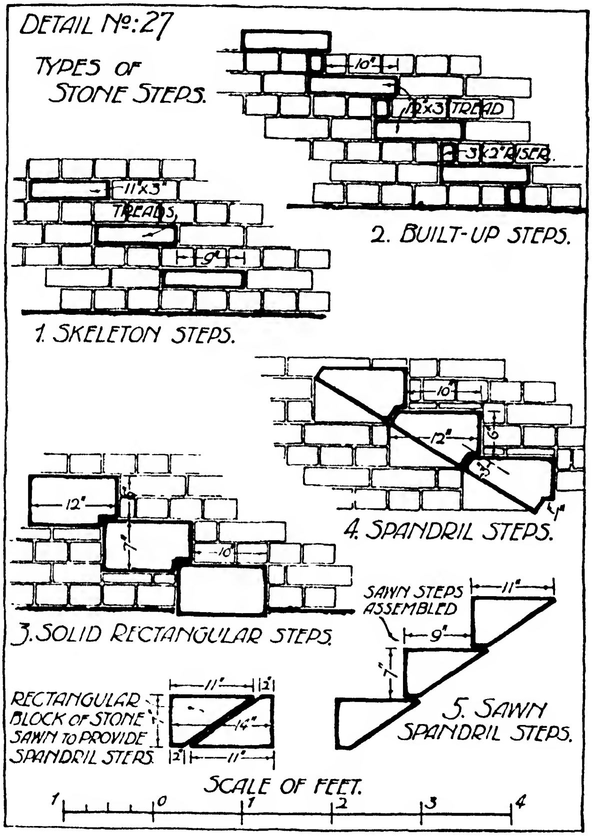
(*d*) The first cost and maintenance.

(*e*) The production of sound by ordinary use.

Iron stairs are little used for buildings except where a staircase must take up very little room, and for external fire-escape stairs. Concrete stairs are of the same nature as stone and for the present may be classed as equivalent when the material is properly selected and compounded.


DETAIL No: 26.
TYPES OF STAIR.
1. THE STRAIGHT FLIGHT STAIR.
LANDING
17UP
15′ 6″
2. THE OPEN WELL STAIR.
¼ SPACE LANDING
LANDING.
18UP
12′ 8″
8′ 6″
3. THE DOGLEGGED STAIR.
½ SPACE LANDING.
10′ 2″
6′ 0″
LANDING

85. Stone stairs. Stairs constructed of stone possess many advantages. They are incombustible; economical in cost and upkeep where in constant use; non-slippery if the selection has been judicious, and fairly sound-resisting when used in thick blocks. They are also easily inserted as the erection of the building proceeds.



On the other hand they are liable to damage under unequal settlement of the supporting walls; they may be damaged by falling materials during erection; some stones disintegrate or even decompose in a fire; and in some districts large blocks of stone suitable for steps are very costly owing to expense of carriage from distant places.

Stairs are commonly constructed of stone in workshops, warehouses, commercial and public buildings and they are also employed

in dwelling houses for cellar and external flights and for entrance steps and thresholds at external doorways.

86. Classification of stone steps. Stone steps are named according to their sectional form or their construction and may be classed under the following types: skeleton, built-up, solid rectangular and spandril, as shown in section at detail No. 27.

87. Skeleton stone steps. This form consists of horizontal slabs of stone 2″ thick and upwards, and 10″ to 12″ wide, built into or upon the supporting walls to serve as treads. These steps are only employed for unimportant positions, such as short external flights and occasionally for internal purposes where the space between the treads would not be objectionable.

A great disadvantage of skeleton steps is their liability to fracture by weighty articles being accidentally dropped upon them. For spans up to 2′ 6″, hard York stone slabs have been successfully used, 2″ thick and for increased spans up to 3′ 0″ a thickness of 3″ is satisfactory; beyond this latter span skeleton steps are not desirable.

88. Built-up stone steps. Where the openings between the treads are objectionable, an economical stair may be constructed by using stone slab risers, in conjunction with the treads employed for skeleton steps as shown in the same detail. The combination is termed a built-up step, and is suitable for either internal or external use, though not so strong nor so sound-resisting as solid stone steps.

As a guide to the dimensions the following may be accepted as the *minimum*: make the treads 2″ thick up to spans of 3 ft. and increase by ½″ for each additional 9″ of span.

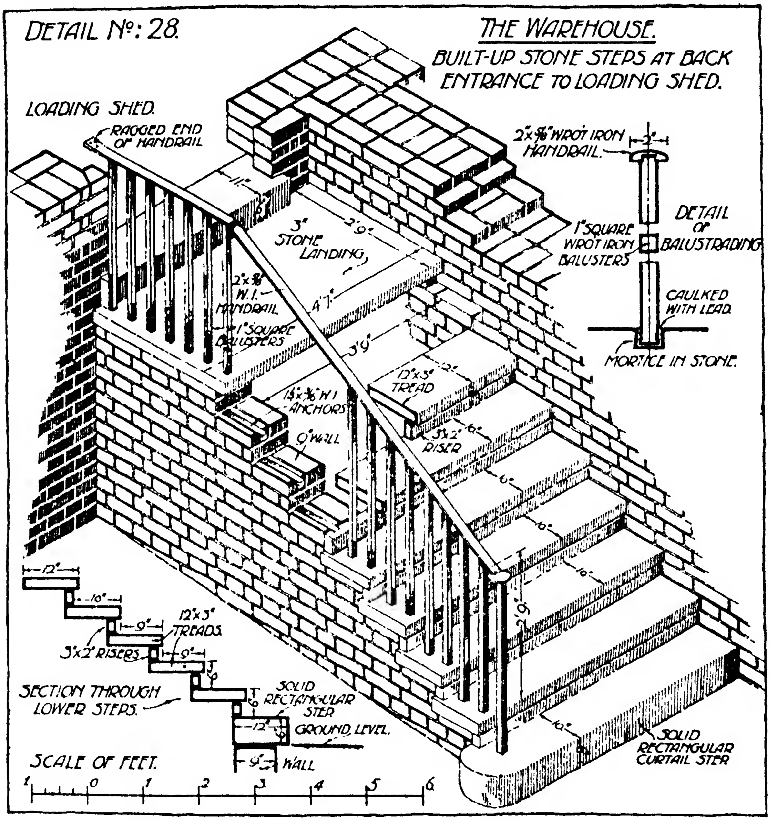
89. Solid rectangular steps. The strongest steps in use are of solid rectangular section. In the simplest form these consist of stone blocks about 12″ × 6″ in cross section arranged with the front edge of one step resting on the upper back edge of the step below and overlapping about 1″. The fault of these steps is that the joint is not covered, and when the bedding or pointing mortar becomes defective a gap is visible.

This defect is improved by rebating the front lower edge of each step to lap over the back edge of the lower step as shown in the detail rectangular .

90. Spandril steps. The term spandril is almost invariably applied to an outline approaching the triangular, and in the case of a step it infers that a triangular portion of the otherwise rectangular section has been removed from the under side of the steps below the joints producing a plane or approximately plane under surface or soffit, when the steps are assembled. This allows of greater head-

room between flights of stairs which are arranged in ~~tiers, than~~ in the case of the solid rectangular steps.

The lower detail of No. 27 shows an economical way in which blocks of stone can be sawn to produce spandril steps, but it is clear that the joint between these is as defective as the joint between



the unrebated solid steps referred to above. This form of step is also without the bearing provided in the better and hand-worked form shown at No. 4.

Stone steps to Warehouse

91. External stair from yard to loading shed. In this example a built-up stone stair is shown at detail No. 28. The span is 3′ 9″, with 12″ × 3″ treads and 3″ × 2″ risers set back 1″ from the front edges of the steps; treads and risers are built 4½″ into the main wall

and entirely overlap the 9″ spandril wall at the open end, projecting 1″ beyond it. The 3″ tread is economical in use because it obviates much brick-cutting.

In stairs subject to rough usage small metal cramps might be used with advantage to secure the free ends of the risers, by housing them into the top edge of the slab, grouting with cement, and anchoring the cramp well back into the joints of the brickwork, as shown in the detail.

Landing to built-up steps. The landing is a 3″ slab of stone 4′ 11½″ × 3′ 1½″ built 4½″ into the walls along two adjacent edges and resting upon the spandril wall and top riser.

This landing slab and all the units of the stair should be of sawn stone which requires little labour in preparation. The edges and ends would be squared and the square nosings and returns possibly tooled in vertical lines.

Solid steps in built-up stairs. The first step in a built-up stair is commonly made solid, to facilitate starting the flight and to ensure secure fixing for the lower balusters or newel; the top step—in this case a threshold to the doorway—may be also advisably solid and supported entirely on the wall. A 12″ × 6″ bottom step and an 11″ × 6″ threshold, both solid, are here employed.

Internal stairs to Warehouse

92. Planning of stairs. In deciding upon the position and size of a staircase for a commercial building and the arrangement of suitable flights of steps within it, consideration should be given to the following points:

(*a*) The staircase should be wide enough to admit of one or more flights of steps of a width which will allow two persons to pass easily.

(*b*) As previously mentioned the staircase should be well lighted and ventilated by windows opening directly to the outer air, and should contain comparatively short straight flights divided by level landings giving easy and convenient access to the floors.

(*c*) Step proportions should agree with the rule previously quoted and the rise should not exceed 7″ for the most frequented stairs. One constant rise of step should be maintained for the stairs contained in one staircase if possible; such deviations from this as may be necessary should be small.

(*d*) Head-room between flights should be at least 7 ft. and may, with advantage, be increased.

In the following examples the least head-room is 7 ft. and occurs under the flight of six steps which land at the second floor level; in other parts of the stair the head-room is greater.

93. Solid rectangular steps. Stairs formed of solid rectangular steps are in common use where stone is easily obtainable or when strength is required, and the head-room between flights is ample.

A short flight of these steps occurs in the entrance hall of the warehouse just within the vestibule doors, and consists of three risers terminating at a 4 ft. landing between the basement and ground floor stairs, see details Nos. 29 and 30.

There are two 11″ × 7″ solid steps with a 1″ square rebate to give an overlap at the back joint and thus provide a 10″ clear going, while the solid landing slab is 6″ thick throughout.

Landings are sometimes made thick enough to allow for rebating at the lower edge over the step, but this is not justifiable for the case in question; 11″ × 6″ plain unrebated steps might have been employed as an alternative, if economy were a special object.

When a flight of steps receives solid support by reason of the lowest step being solidly bedded, the whole flight is stiffened, because when a step receives its load and begins to sag the deflection is in a measure resisted by the whole series of steps having solid contact with each other. In the present example the bottom step rests upon a 9″ wall which also supports the concrete floor of the entrance hall; adequate support is thus afforded over a wide span.

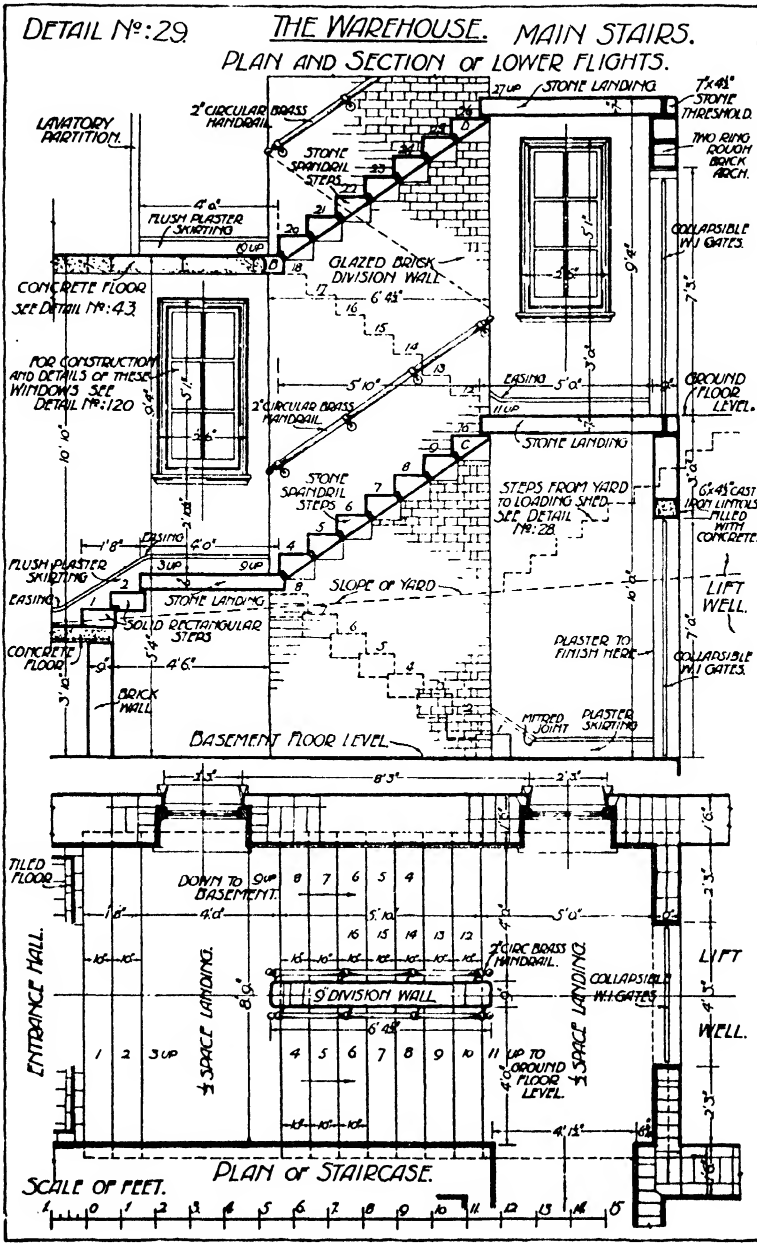
Basement stair. Solid rectangular steps are employed for the basement stair, as shown in dotted lines on the detail. These would have been equally suitable for the main stairs of the warehouse, provided that ample head-room was available at every part.

94. Spandril steps. For the bulk of the main warehouse stair spandril steps have been adopted.

A typical section of a flight of spandril steps is given in detail No. 29, which indicates the arrangement and construction of the lower part of the main warehouse stair.

Each step is obtained from a solid rectangular block of stone, 12″ × 9″, cut to provide a 10″ going and approximately a 7″ rise; each step receives support at its ends upon the enclosing and intermediate walls, and has square bearings left upon the ends for that purpose. Between the bearing ends the spandril surface is formed by cutting away a triangular portion which would protrude below the desired soffit plane.

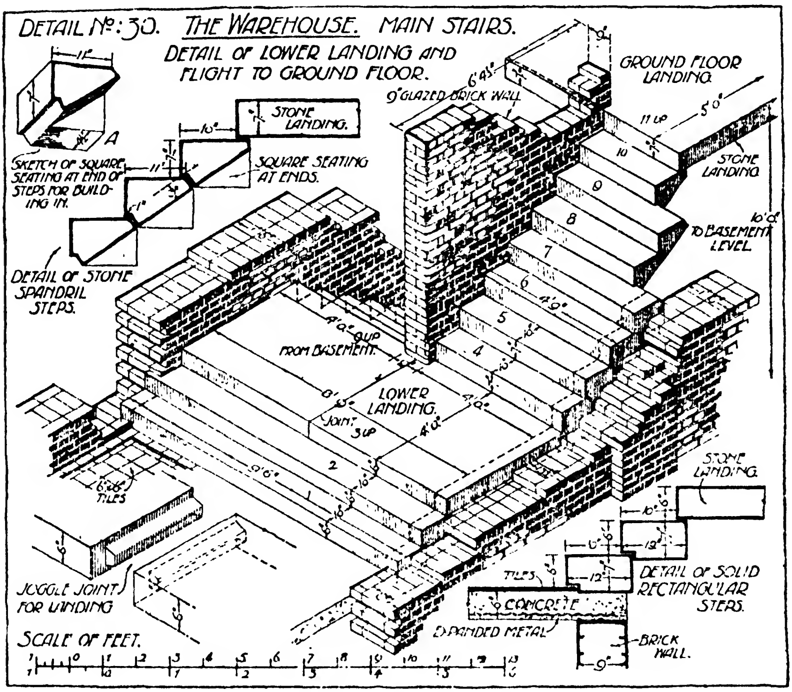
The isometric detail, No. 30, of this portion of the stair illustrates at A the bearing end of a step with its level seating and the stop of the spandril, and also shows how the rebated back edge is formed with the two surfaces of the rebate each at right angles to the face from which it is recessed; as stated in Vol. I, this is a general principle of masonry jointing. The rebates should not be less than 1″ on the horizontal and $1\frac{1}{2}''$ at right angles to the soffit.



DETAIL Nº:29
THE WAREHOUSE. MAIN STAIRS.
PLAN AND SECTION OF LOWER FLIGHTS.
STONE LANDING
7"x4½" STONE THRESHOLD.
TWO RING ROUGH BRICK ARCH.
2" CIRCULAR BRASS HANDRAIL
LAVATORY PARTITION.
STONE SPANDRIL STEPS
FLUSH PLASTER SKIRTING
COLLAPSIBLE W.I. GATES.
GLAZED BRICK DIVISION WALL
CONCRETE FLOOR SEE DETAIL Nº:43
FOR CONSTRUCTION AND DETAILS OF THESE WINDOWS SEE DETAIL Nº:120
EASING
GROUND FLOOR LEVEL.
STONE LANDING
STEPS FROM YARD TO LOADING SHED SEE DETAIL Nº:28
6"x4½" CAST IRON LINTOLS FILLED WITH CONCRETE.
FLUSH PLASTER SKIRTING
SLOPE OF YARD
LIFT WELL.
EASING
STONE LANDING
SOLID RECTANGULAR STEPS
CONCRETE FLOOR
PLASTER TO FINISH HERE
COLLAPSIBLE W.I. GATES.
BRICK WALL
MITRED JOINT
PLASTER SKIRTING
BASEMENT FLOOR LEVEL
TILED FLOOR
DOWN TO BASEMENT.
2" CIRC BRASS HANDRAIL.
ENTRANCE HALL.
½ SPACE LANDING.
9" DIVISION WALL
COLLAPSIBLE W.I. GATES
LIFT WELL.
UP TO GROUND FLOOR LEVEL.
½ SPACE LANDING.
PLAN OF STAIRCASE.
SCALE OF FEET.

95. Setting out of main stair. Some attention should now be given to the complete arrangement of the stairs.

In the warehouse are required a series of flights and landings for suitable access to the main floors of the building and also to the intermediate floor levels of the lavatories, which are placed in a tier over the main entrance. The selected method is to employ two



or more flights of steps between each pair of main floor levels, arranged as shown on detail No. 31. The flights are divided by a 9″ wall which provides support to the inner ends of the steps.

96. Lift of main warehouse stairs. A reference to the general plans will show that the lift or total rise from basement to upper floor is made up as follows:

From basement floor level to ground floor level, 10 ft.

From ground floor level to first floor level, 14 ft.

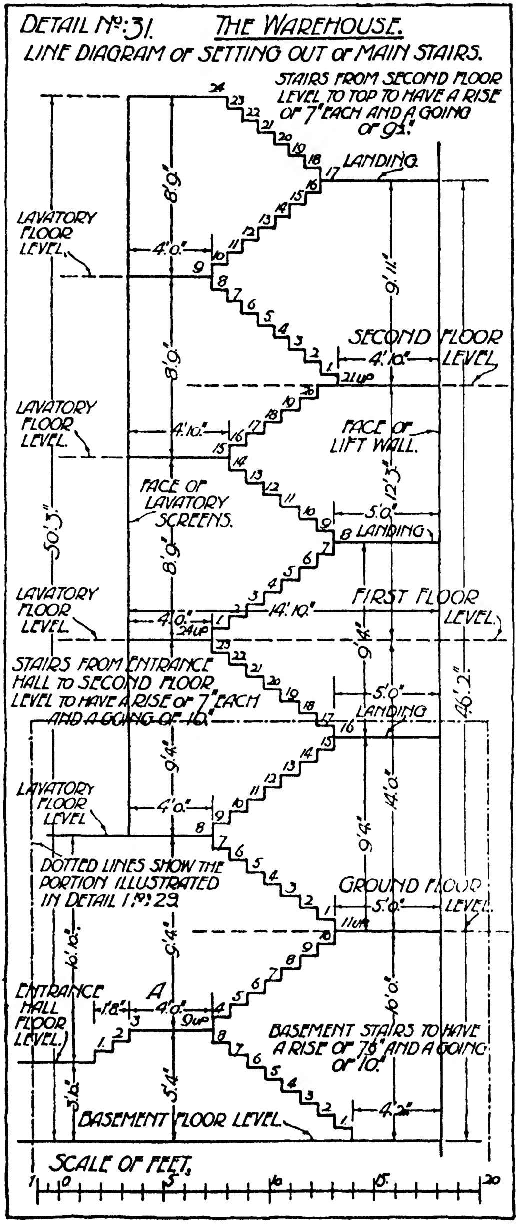
From first floor level to second floor level, 12 ft. 3 in.

The stairs continue from the second floor level, to provide access to the top lavatory floor by an intermediate landing and also to the flat roof and lift enclosure.

Adopting a height of 9′ 4″ from the first landing at A in detail No. 31, to the floor level of the first lavatory and an equal height between the floor levels of the first and second lavatories, it is found that by adopting a common height of 8′ 9″ from floor to floor and floor to roof for the remaining lavatories, steps having a 7″ rise can be used for all the stairs above A. With the exception of the basement stair, the whole of the steps of the main stairs will therefore be of spandril section having a 10″ going and 7″ rise thus adhering sufficiently well to the rule for step proportions given in Vol. I.

The basement flight has a lift of 5′ 4″ which requires, say, 9 risers at $7\frac{1}{9}$″ each; the steps are solid rectangular ones and must be worked to an entirely different pattern from the steps in the main stairs, and there is no objection to such a slight change in rise.

The line drawing



of the setting out will make the arrangement of flights clear if read in conjunction with the plan and section in detail No. 29. The number of steps in each flight is given and all floor levels shown.

97. Landings. The term landing means a level platform which may be a floor level or an intermediate resting place.

While an actual resting place is not intended for a person to halt at during ascent or descent, landings do present a mental restfulness to the user, giving a sense of security always lacking in a long unbroken flight of steps.

Landings at floor levels are named main or floor landings, and all others intermediate landings; these latter will need further special names according to their dimensions and disposition.

In the warehouse stairs the landings occupy the full width of the staircase and are usually named "half-space" landings; they may be formed of 7″ slabs of stone built 4½″ into the wall at each of their wall edges, except at the lavatory floor levels, where they are constructed of steel and concrete and form a continuation of the lavatory floors.

It is quite a usual thing for the whole stair and landings to be constructed in concrete, the steps being often precast, though they may also be cast *in situ*.

98. Joggled joints in landings. Where sufficiently large stones are obtainable, landings are formed in one piece of material if the circumstances permit; in other cases it may be expedient or necessary to joint the edges of the slabs as shown in detail No. 30. This joint is called a "joggle" and consists of a tapered tongue about 2″ thick and 1½″ projection on one piece of stone, with a corresponding groove on the other piece; the taper facilitates placing in position and flushing with mortar. The tongue is stopped 2″ or more from the end, which hides the joggle where necessary. Joggles serve the purpose of (*a*) closing the joints, which would otherwise allow dust to work through, (*b*) preventing displacement of the pieces, (*c*) ensuring more careful and accurate setting in position.

Landing slabs are sometimes made thicker than the rise of the step, to allow for the formation of a bevelled rebate on the lower front edge identical with the jointing of the steps; this is a waste of material and justifiably omitted in this case; it should also be noted that no thrust is transmitted from a landing slab, hence the rebate is unnecessary for this purpose. The landing should lap 2″ over the top step with the joint bedded in mortar.

99. Special steps and landing slabs. The special treatment of the steps at B, C and D should be noted here, as shown in the vertical section of detail No. 29. B is a termination stone at the edge of the steel and concrete floor upon which the upper flight abuts, the back edge being left vertical as there is plenty of headroom below.

In any case where head-room is small this angle may be splayed to continue the soffit line of the stair.

This stone is built $4\frac{1}{2}''$ into the walls at each end and the edge abutting on the floor concrete is joggled $\frac{1}{2}''$ deep to receive the concrete and break the straight joint.

The top steps of the two flights in this detail, marked C and D, have the back edges finished plumb and to the full width of the step block and are utilised to provide overlap for bedding, in the absence of a rebated joint.

100. Building the stairs and staircase. The warehouse steps, being built into the supporting walls at each end and thus forming a closed stair, must be erected as the building of the walls proceeds. Each step is set accurately in position, its level being tested with the "storey rod" for the storey which is proceeding—see Vol. I. Brickwork under and around the bearing ends of the steps is neatly cut and thoroughly bedded in slow setting mortar, unlike that for the staircase walls which should set fairly quickly. This precaution is taken to avoid any undue settlement of the staircase walls causing fracture of the steps. The principle of this procedure has been previously enunciated in connection with the bedding of window cills—see paragraph 33.

With jointed steps it is not always possible to arrange the bearing levels to coincide with the coursing joints, and in some cases awkward cutting of the brickwork is unavoidable. To ensure sound bearing surfaces in such cases, where the bricks are hard and difficult to cut, thus causing irregular beds, cement mortar should be employed for the cut courses immediately under the bearing ends of the steps.

101. Staircase walls. For the purpose of obtaining satisfactory distribution and reflection of light the walls of the staircase might be finished internally with glazed or enamelled bricks or tiles of a suitable colour, which may be arranged to form a dado following the rake of the stair, or a series of panels between the steps and the soffit above.

If common brick must be employed the walls may be plastered, as indicated on the plan of detail No. 29, and a plaster skirting carried around the entrance lobby up the rake of the stair and round level landings; or, the brickwork may be finished with neatly pointed joints, or finished with flush joints for a flatting paint or distemper finish.

Junctions between the mouldings of the level and inclined skirtings may be either straight mitres bisecting the angle of intersection or made by introducing a curve tangentially joining the level and raking lines. The latter method is preferable and forms what is technically known as an "easing".

CHAPTER FIVE

MASONRY

General Design and Construction

Consideration will now be given to external stonework as embodied in a masonry façade of some importance.

102. Façade. A façade is a principal face or elevation of a building, and, as such, demands some effort of design. The front of the warehouse is an example.

Two designs are given, one in masonry fully developed and detailed, and the other in brick, treated in the modern style as shown in the frontispiece of this volume. The latter is intended as an example for the individual student to analyse and detail for himself, as part of his course of study.

103. Warehouse façade. The general drawings of the warehouse give a comprehensive idea of the design adopted in the main façade, part of which will be considered here in detail.

The main portion of the front, excluding the staircase and lavatories on the left of the elevation, occupies a height of about 47 ft. from pavement to cornice and a width of 39 ft. from out to out of the pilasters.

There are four storeys each having three windows in the façade; the basement windows commence at the pavement level and stand 5′ 7½″ above it, while the other windows occupy an average position in relation to each storey with the cills 2′ 6″ to 3 ft. above the floor levels.

104. Subdivision of façade. The main portion of the façade consists of a base or plinth, a surbase extending to the first floor level and a superstructure comprising pilasters extending through the height of two storeys and surmounted by an entablature and parapet.

The intention of the design is to give the appearance of good support to the groundwork of the structure and to this end the base and surbase are given adequate projection beyond the main face of the work, thus providing a strong sense of support to the superstructure.

The staircase and lavatory portion of the façade, on the left, is treated to harmonise with the main portion but the windows are at different heights as necessary to the scheme of internal accommodation. The main face of this portion is also set back from the principal

part of the façade and the entire treatment produces a lighter mass and hence a secondary effect.

105. Entrance. The main entrance to the building is in this side wing and a goods entrance is placed alongside, giving access to the yard and loading shed.

The main doorway is enclosed by sunk panelled architraves and surmounted by a cornice. The architraves have only a small projection but the reveals of the doorway are wide and a deeply recessed opening is thus formed giving distinction to the entrance by broad cast shadows. The yard entrance door is set within a suitable enclosure of masonry, harmonising with its surroundings, but recessed and discontinued from the main front and entirely a subordinate feature.

106. Treatment of lower storey. In this volume the detailed construction of parts of the lower storeys only are given.[1] As a foundation for the design of the façade we have already seen that the lower storey is made to project beyond the superstructure; the surface is also treated in a manner suggestive of strength, with rock faced plinth courses and base mould, above which is channel jointed ashlar filling, capped by a heavy string course which is weathered and lightly moulded.

The lower storey contains the windows lighting the basement and ground floor and these are designed to harmonise with the surrounding work.

107. Basement window openings. A simple treatment has been adopted for these openings as shown in detail No. 32. The openings penetrate the masonry plinth and rise 1′ 3″ above it; the plinth projects 3″ in front of the surbase masonry and this projection is maintained to form the window opening in the same plane.

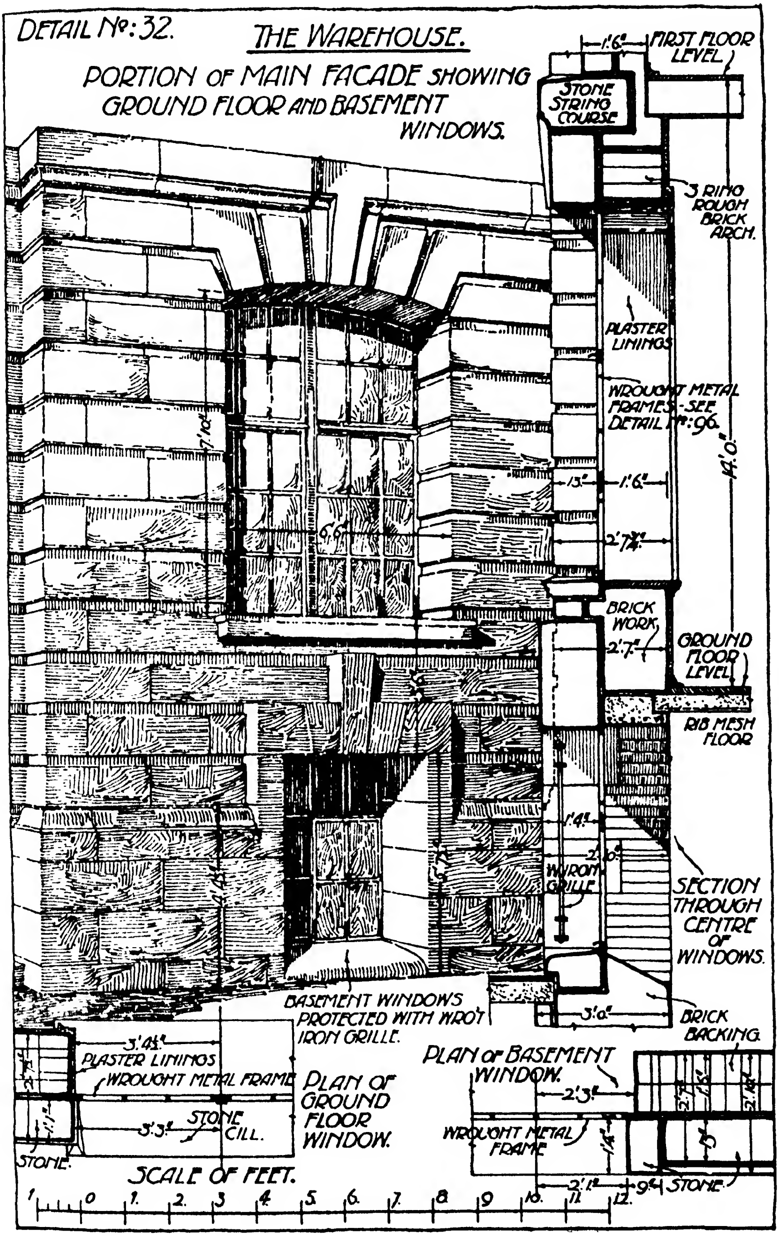
The jambs of the windows are 9″ wide and the flat arch spanning the opening is 15″ deep, keyed by a splayed block 2′ 6″ deep.

The reveals to the opening are 16″ wide and at right angles to the face, while the recesses are only $1\frac{1}{2}$″ deep for the reception of metal casement frames; the cill is formed from one block of stone 5′ 4″ long, 16″ × 12″ in section, and enters the jambs 7″ at each end. On the upper surface the cill is splayed and rounded, and on the lower edge is rebated to receive and overlap the pavement.

Note that the horizontal joints of the jambs and arch coincide with the top edge of the channels in the joints of the surrounding stonework.

A metal grill is housed to the stonework of the reveals as a protection to the window.

[1] For the entrance doorway and the superstructure of the façade see Vol. III.


DETAIL No: 32.
THE WAREHOUSE.
PORTION OF MAIN FACADE SHOWING GROUND FLOOR AND BASEMENT WINDOWS.
FIRST FLOOR LEVEL
STONE STRING COURSE
3 RING ROUGH BRICK ARCH.
PLASTER LININGS
WROUGHT METAL FRAMES - SEE DETAIL No: 96.
14'.0"
BRICK WORK.
GROUND FLOOR LEVEL
RIB MESH FLOOR
W. IRON GRILLE
SECTION THROUGH CENTRE OF WINDOWS.
BRICK BACKING
BASEMENT WINDOWS PROTECTED WITH WRO'T IRON GRILLE.
PLASTER LININGS
WROUGHT METAL FRAME
STONE CILL.
STONE.
PLAN OF GROUND FLOOR WINDOW.
PLAN OF BASEMENT WINDOW.
WROUGHT METAL FRAME
STONE
SCALE OF FEET.

108. Ground floor window opening. The openings for the ground floor windows are 7′ 10″ high to the springing line of the arch and 6′ 6″ wide, and are constructed in the channelled stonework without any projections, as shown in detail No. 32. A segmental arch spans the opening, having its voussoirs channelled to harmonise with the horizontal courses, the voussoirs and key being continued to the string course, which they immediately support.

The jointing of this arch is probably a new feature to the reader because of the stepped outline of the outer voussoirs; these should be dissociated and sketched separately. A further reference to this arch is made in paragraph 113.

109. Lavatory windows. The lavatory windows are arranged in one tier above the main entrance doorway—see general drawings and detail No. 33—and for purposes of design are treated as two pairs of windows, each pair becoming a unit in the design.

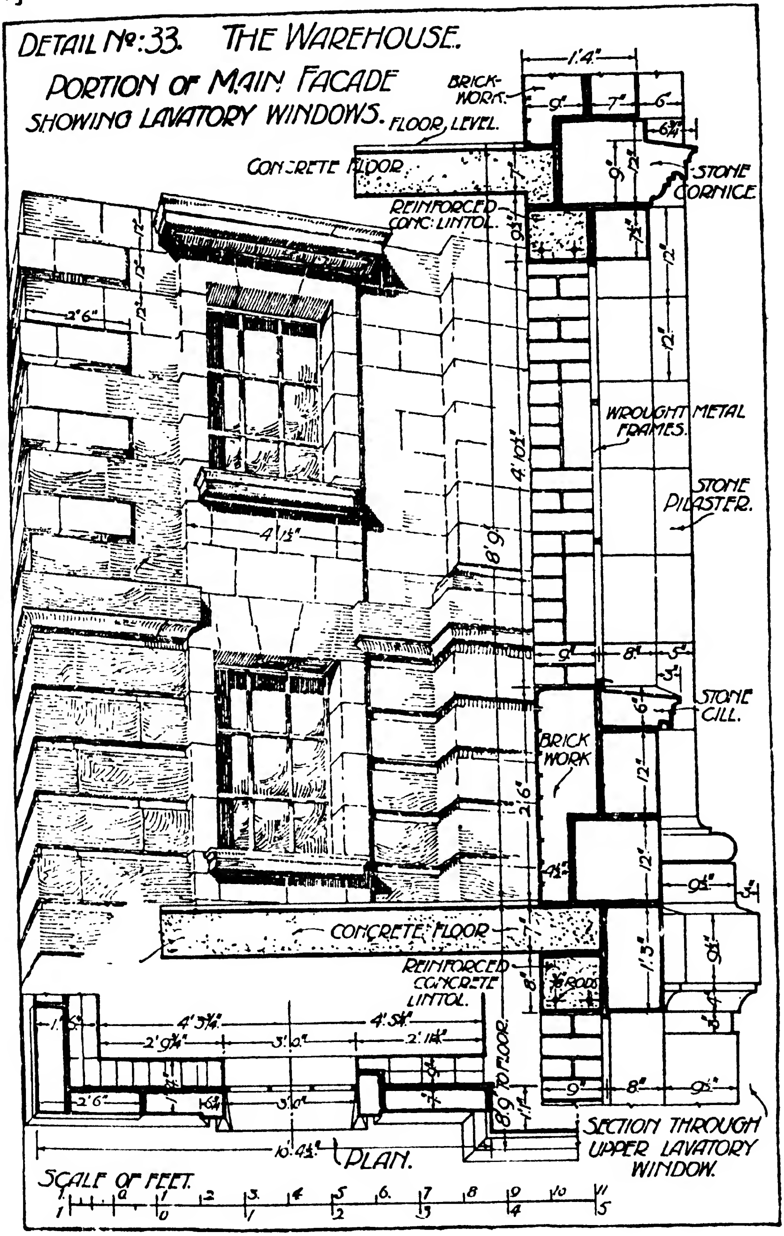
This unit consists of a rectangular panel having a projection of 1″ from the surrounding wall, which, in the lower unit measures 15′ 5½″ high × 4′ 1½″ wide, and encloses two window openings 5′ 0″ × 3′ 0″ on the first lavatory floor and 4′ 10½″ × 3′ 0″ on the second. Plain margins and reveals are employed together with moulded stone cills identical with those previously described and illustrated. A stone cornice 9″ deep forms the crowning feature of the panel, and the heads to the openings are flat stone arches. These arches are differently treated, the upper one being a plain arch of uniform depth, except at the springers, where a rebated internal angle is necessary to keep the coursing joints on the same level at the first bed joint below the soffit; the rebated arch to the lower window is 15″ deep, and though consisting of five stones is similar to that illustrated in detail in Vol. I.

110. String course. The moulded string course which is carried across the main façade at the first floor level, is broken at the head of the first lavatory window to avoid interference with the projecting panel containing the two openings, and this moulding is conveniently returned at the edges of the panel and stopped against the face of the arch and serves also as a finish to the rusticated courses of the lower stories.

Arches

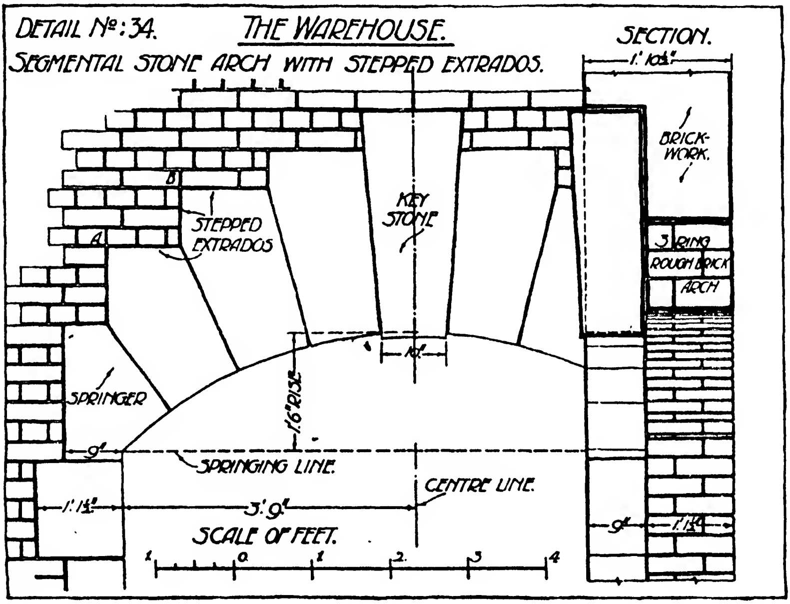
111. Stone arches. Reference has already been made above to flat stone arches, which were first dealt with in Vol. I, and some study has been given to various forms and applications of brick arches.

It is now convenient to note the features in which curved stone arches have been selected for use in the warehouse.


DETAIL No:33. THE WAREHOUSE.
PORTION OF MAIN FACADE
SHOWING LAVATORY WINDOWS.
BRICK-WORK.
FLOOR LEVEL.
CONCRETE FLOOR.
REINFORCED CONC: LINTOL.
STONE CORNICE.
WROUGHT METAL FRAMES.
STONE PILASTER.
STONE CILL.
BRICK WORK
CONCRETE FLOOR
REINFORCED CONCRETE LINTOL.
8'9" TO FLOOR.
SECTION THROUGH UPPER LAVATORY WINDOW.
PLAN.
SCALE OF FEET.

112. Segmental arch with stepped extrados. In the back elevation of the warehouse segmental arches are employed to support the walling over the ground floor windows, which have a span of 7′ 6″.

Detail No. 34 shows a stone arch with a rise of 1′ 6″, having a stepped extrados of suitable outline and dimensions for bonding with the brickwork. The arch is 9″ long, built with nine voussoirs, gradually increasing in depth from the springing to the crown.



When masonry and brickwork are compounded as in this example a stepped extrados is always advisable, but it may also be employed with advantage in all walls where the coursing and size of voussoirs will allow of a pleasing arrangement.

The principle employed in arranging the voussoirs is to diminish the number of courses in depth at each vertical step from the springer inwards and to increase the width of the steps towards the centre of the arch.

In this example the key stone provides a dominating feature by projecting from the face and soffit of the arch. The taper of the keystone on the bevelled face is commonly made to agree with that on the sides of the key, as measured from the centre line of the arch. This uniformity of bevel is not a necessity, but forms a safe guide to the inexperienced student.

The springer of the arch is rebated on the internal angle as in a previous example because the springing line of the arch does not coincide with a bed joint of the brickwork.

113. Segmental arch with stepped and bonded voussoirs. In detail No. 32 it was noted in a previous paragraph that the ground floor window openings of the front elevation were spanned by stone arches of segmental outline; these have a span of 6′ 6″ and a rise of 8″ and are varied in treatment from the plain arch to harmonise with the surrounding stonework which is emphasised with 3″ × 1″ horizontal channels along the top edges of the courses; these channels are continued along the corresponding radial edges of the voussoirs and returned across the soffit of the arch. It was found convenient in this example to form the first voussoir above the springing with a horizontal step or key bonding into the courses of the stonework.

Some arches of considerable size and importance are constructed entirely with bonded and keyed voussoirs, while others have a number of the voussoirs near the springing so treated. The method is expensive but architecturally effective where great weight has apparently to be borne; the principle is useful in connection with arches of double curvature, niches, etc., which occur in more advanced work.

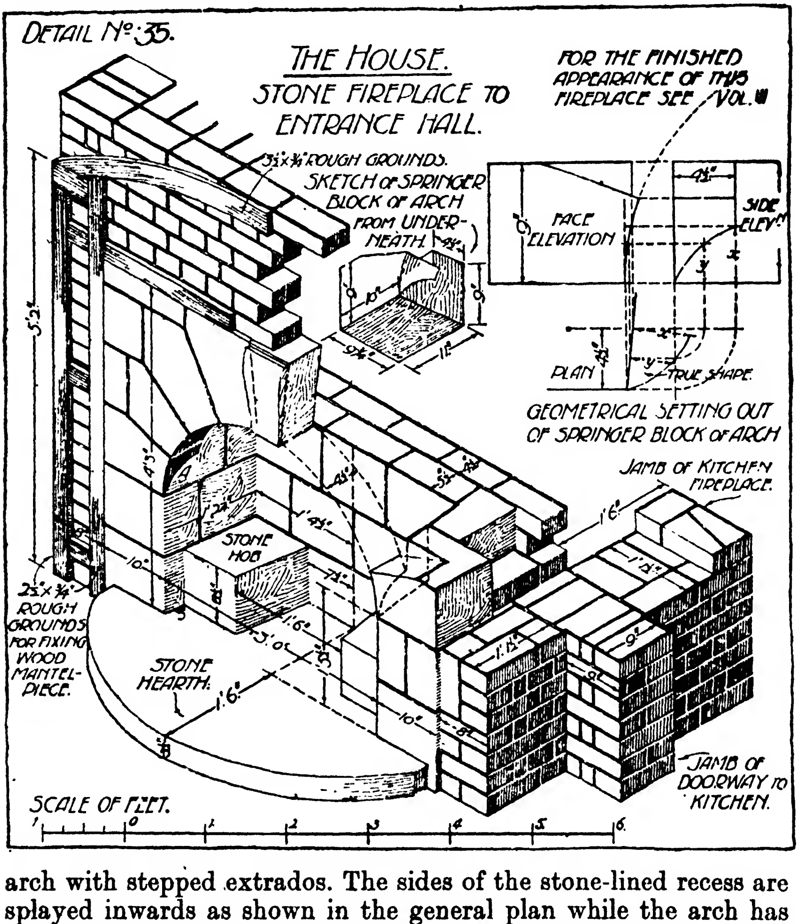
Semicircular arch. An example of a similar but semicircular arch with a stepped extrados was shown in Vol. I; the steps in this case were varied to suit the stonework coursing.

114. Semi-elliptical arches with stepped voussoirs. The semi-elliptical arch in stone—inserted in brick or stone walling—is quite a common building feature, used over shop front openings, waggon ways and similar positions where height is lacking and a personal preference for the ellipse prevails. A good exercise for the student is available by detailing a semi-elliptical stone arch with stepped voussoirs, inserted in the brickwork of the entrance to the loading shed.

Details Nos. 17 and 18 give the necessary dimensions and information for the exercise; the stepping should be arranged to suit the brick bond and to avoid unnecessary brick cutting.

115. Entrance to yard from front street. A further exercise is available for the student, viz. to detail the masonry surrounding the entrance to the yard from the front street, utilising the small scale outlines indicated on the general drawings and composing the mouldings and ornament, coping, etc. to harmonise with other and adjacent parts of the building which have been fully detailed in the preceding pages.

116. Internal stone arch to fireplace of entrance hall. A stone[1] fireplace with a wood mantelpiece is intended to be placed in the entrance hall of the house, and the arrangement of the stonework in conjunction with the brickwork is shown in detail No. 35. The fireplace opening is 3 ft. wide and spanned by a semicircular stone



arch with stepped extrados. The sides of the stone-lined recess are splayed inwards as shown in the general plan while the arch has a cylindrical soffit, hence the intersection of the latter with the sides produces the curved line at A in the isometric detail.

To determine the outline in side elevation, of this intersection or "die on", points on the curve must be obtained by geometrical construction, as shown in the detail.

[1] See Chapter on Materials for suitable stones.

In the same detail is shown one of the jambs of the kitchen fireplace and of the doorway leading from the hall to the kitchen. A $3\frac{1}{2}''$ solid stone hearth with a segmental front is also suggested, resting upon the concrete floor.

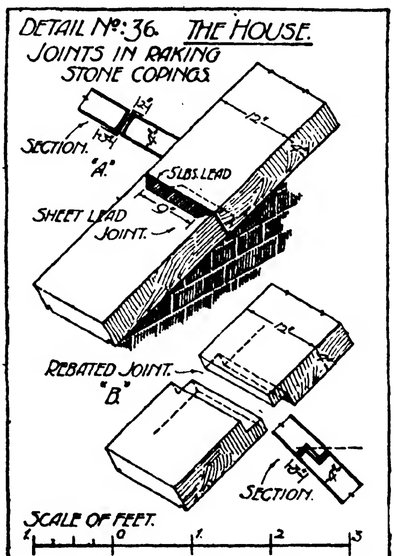
The fireplace is intended to receive a small "dog" or "basket" grate and stone hobs are provided at the sides.

Rough wood grounds are also indicated for the fixing of the wood mantelpiece, for which see Vol. III.

Raking Copings

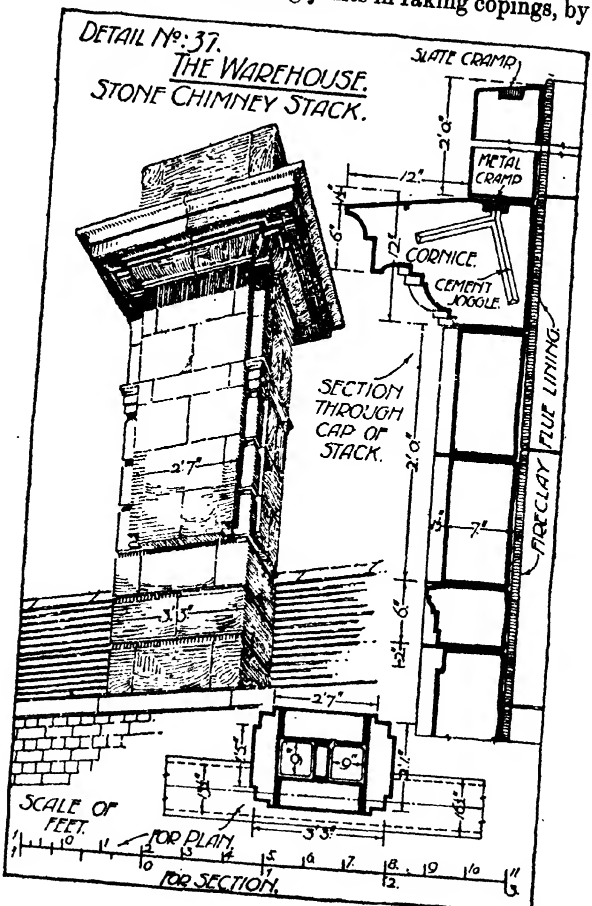
117. Joints in raking copings. In Vol. I, the necessity of making copings water-tight at the joints was emphasised, especially where the wall to be covered is a continuation of an important wall such as the external or party wall of a domestic building. The method of plain butt jointing in cement mortar is only suitable for steep pitched copings, *e.g.* 45° and over. For flatter pitches, and for all important work, one of the following methods is to be preferred.

118. Lead lined joint. Detail No. 36 shows a $12'' \times 4''$ raking coping for the party wall parapet between the two houses, or any similar position, where a plain square joint is rendered water-tight with 5 lbs. sheet lead. The lining consists of a piece of lead $12''$ wide $\times$ at least $10''$ long, bent and cut as shown, and inserted in the joint, which is made with cement mortar in the ordinary way. Any water leaking through a defect in the joint or absorbed by the mortar is held up by the underlap of the sheet and serious leakages are transmitted to the outer edges if the bed of the coping is left clear of the mortar at the lower angle. For perfect safety the underlap should be long enough to rise to a higher level than the external angle; it is then impossible for water which is accidentally held up in the joint to overflow into the body of the wall. The exposed angles are bevelled away from the edges of the coping to avoid undue disturbance by the wind; if the coping is



moulded at the projection, the lead sheet must be cut to the profile of the mould.

119. Rebated joints to copings. The same detail also illustrates a common method of preparing joints in raking copings, by rebated



ends. The underlap of the rebate is necessarily on the lower stone and the proportions of the joint should be such as to safeguard the overflow of collected water within it; this is accomplished in a similar manner to that described in the last paragraph, viz. by carrying the underlap at least to the level of the dotted line shown in the detail.

Stone Chimney Stacks

120. Stone chimney stack to warehouse. Surmounting the coping to the party wall of the warehouse a two-flue stone stack is indicated in the general drawings and is further illustrated in detail No. 37. The main portion of the stack is of ashlar masonry with channelled joints, the upper part of each face having a plain stone apron worked as a projection on the stones. A solid necking mould is cut around each angle and stopped against the aprons, thus providing a plain frieze above, which is surmounted by a 12″ deep moulded cornice and blocking course 2 ft. high.

The bonding of the courses forming the body of the stack is indicated in the detail, and consists of long and short quoin stones alternately placed in opposite directions from the angle, with plain fillings between them on the longer sides. The cornice projects 12″ and is obtained from two blocks of stone which are sunk to form the flues; these units are prevented from being displaced by cement joggles and are also connected on the top surface by metal cramps across the joints. The blocking course is in five stones similarly cramped together on the top surface and often slate dowelled to the top bed of the cornice.

The flues are formed with fireclay flue linings, see paragraph 72 and detail No. 23.

CHAPTER SIX

STRUCTURAL IRON AND STEEL WORK

Bressummers and Lintols

121. Lintol. The term lintol will be applied to those beams, of whatever material, which are used to span an opening to be subsequently filled in with doors or windows.

Bressummer. A bressummer is distinguished from a lintol, in that the opening is not closed by any frame or fitting immediately below the beam. In both cases the beam is intended to support walling erected directly upon it.

Many types of lintol and bressummer are in general use in addition to those illustrated and described in Vol. I.

Several forms are illustrated in the different details included in this volume, but in order to compare the sections which are available for a particular purpose the opening between the ground floor and loading shed of the warehouse has been selected for the application of various forms of bressummers.

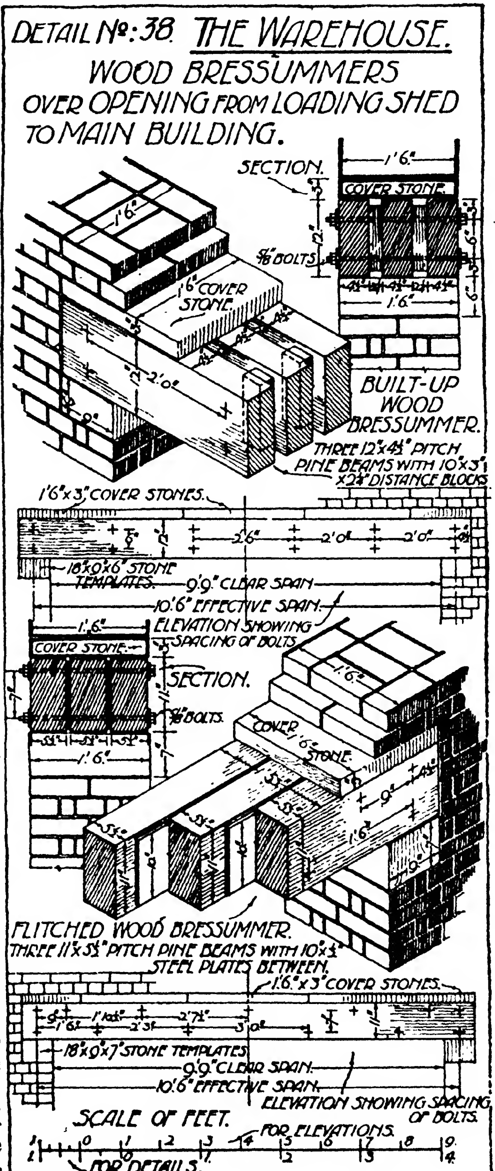
The opening is 9′ 9″ in the clear between the jambs, which, allowing 9″ bearings, gives an effective span of 10′ 6″ between the centres of the bearing surfaces; the wall to be carried is 18″ thick.

122. Wood bressummer. A wood bressummer would be out of place in such a position, for a fire-resisting structure, but supposing it to be selected, sufficient strength to carry the walling and girder loads from above would be provided by three 12″ × 4½″ pitch pine slabs or flitches packed apart and bolted, as shown in detail No. 38 forming what is known as a built-up beam; see also Vol. I.

The advantage of building up from slabs is that the material can be better inspected before using and is also in a more seasoned condition when inserted. Free play of air round the material and between the slabs assists in its preservation.

If the heading course of brickwork is the first to be laid above the bressummer, it may be placed directly thereon; otherwise it is well to insert a course of 3″ flat stone slabs to distribute the load.

123. Flitched wood bressummer with steel plates. In the event of the maximum possible load coming upon the bressummer—which presumes that a secondary floor girder comes centrally over it—the wood lintol would not be strong enough.



Suppose that Northern pine timber is to be employed and restricted to a depth of 11″, then, by inserting plates of steel between the slabs of timber a stronger bressummer would be obtained. This is an expensive method and is not advocated in modern work, except in special circumstances.

Calculations[1] show that sufficient strength would be provided by three 11″ × $5\frac{1}{2}$″ slabs, with two 10″ × $\frac{1}{2}$″ steel plates interleaved as shown in the lower part of detail No. 38, thus forming what is generally known as a steel-flitched timber girder. In bolting these together a zigzag or chequered arrangement should be adopted as shown in elevation, the lines of bolts being 7″ vertically apart.

It is sometimes urged that the bolts should be chiefly placed through the compressional part of the beam, viz. above the centre line, and as few as possible below this line. This is a mistake because the additional strength gained from the steel plates depends upon the two materials acting

[1] For calculations see Vol. III.

together and this is only possible by gripping them sidewise so tightly that the friction set up between the parts, and the shear resistance of the bolts themselves, are sufficient to prevent any slipping of the pieces over each other. Hence, for satisfactory stressing of the beam we should have approximately the same number and disposition of the bolts above and below the centre line. Chequered spacing is employed to avoid unduly reducing the cross section in one vertical plane.

In all flitched beams the steel plates should be made narrower than the timber so that there is no danger of the narrow band of steel riding upon the stone template, or of the brickwork, etc., above, resting insecurely upon the plates. Loads concentrated on such narrow bands of hard material would cause the stone template or bricks to snap or crush under the intense pressure.

124. Rolled steel sections of I,[1] C or L form.

B.S.B.'s. A most suitable form of bressummer for this position would be two **I** beams placed as shown in the lower part of detail No. 39, and made to act together by accurately fitted cast iron or steel separators or stiffeners placed between the flanges and webs, and bolted rigidly at about 3′ 6″ centres.

Two B.S.B.'s each 8″ × 4″ × 18 lbs. per ft. are required for this opening. If placed as illustrated with the heading course of brick laid immediately and centrally over them, stone distributing slabs are unnecessary.

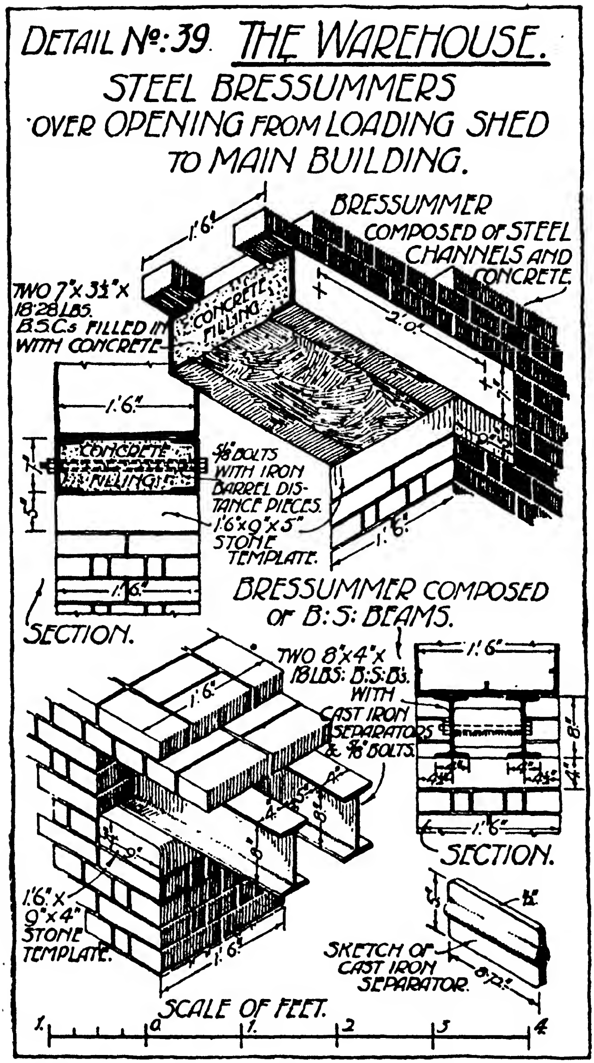
If the space between the beams is left exposed there should be sufficient space to give access for painting.

Steel channels. The same detail shows how steel channels may be satisfactorily employed, where two B.S.C.'s each 7″ × 3½″ × 20·25 lbs. per ft. are selected, placed with their flat faces flush with the surface of the wall and kept at this position by distance pieces of wrought iron barrel, cut to length, and gripped by ⅝″ bolts at about 2′ 0″ centres.

The space between the channels is best filled with concrete as shown in the detail; such filling thoroughly protects the interior from oxidation, leaving only the easily accessible faces and soffit to be painted for protection.

As an alternative the channels might be spanned by stone slabs and the wall carried thereon, leaving the interior of the channels exposed and painted. In this case the deep cast iron separators illustrated in the previous detail should be employed. Wrought iron barrel distance pieces are only satisfactory when surrounded by a rigid filling, such as concrete.

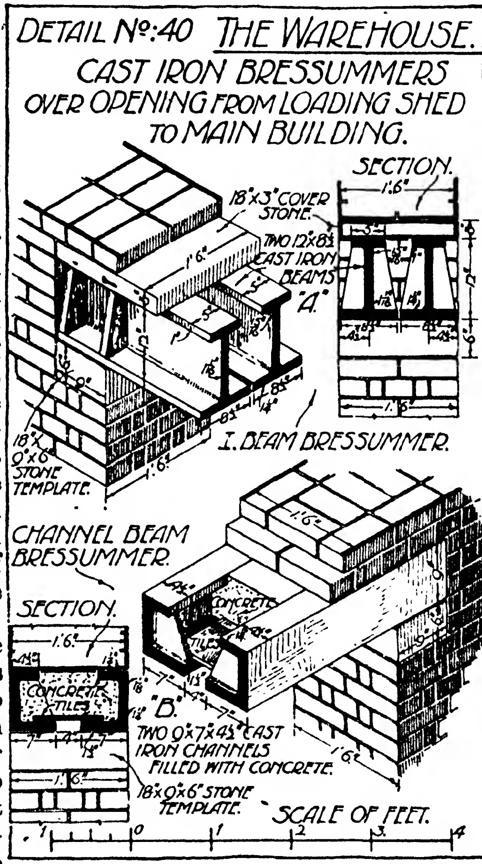
[1] For calculations see Vol. III.



Steel angles. Steel angles could be used in the same manner as the channels, placing the tables to appear on the soffit and filling up the interior with brick or concrete.

The method is uneconomical as very heavy sections are required to produce the necessary resistance to bending.

125. Cast iron bressummers. While cast iron is diminishing in use for structural work and is largely confined to a few districts, cast iron bressummers *may* be employed in either of the forms shown in detail No. 40. At A, are shown two ordinary cast iron beam sections, laid side by side and set ¼″ inwards from the faces of the wall. The parts of these beams are named exactly as for steel **I** beams, but it should be noted that the top flange is much less in sectional area than the lower flange for the reason explained in Vol. III. In this example the end bearings are only 9″ long and, though walling is built directly over the bearings, the ends cannot be considered as fixed; if such were the case the top and bottom flanges would be of equal section and the girder of symmetrical outline like an **I** beam.

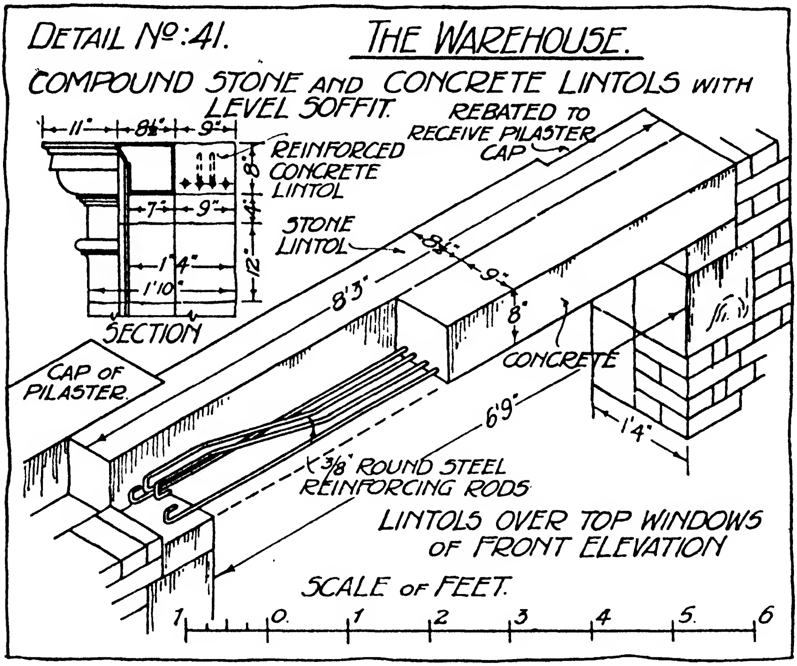


To prevent curvature of the wider flanges when casting and also to strengthen them transversely under their loads, it is necessary to provide stiffeners, cast in solid attachment between flanges and web as shown in the detail, at centres not exceeding 3 ft. Stiffeners are required immediately over the edge of the support and at the extreme end of the bearing. The internal angles are all rounded or slightly splayed to ease off any abrupt change in direction of the surfaces.[1]

An alternative form of bressummer is shown at B, where the exposed faces are flat, giving an irregular channel section.

[1] See also Chapter on Materials.

In the first example the narrow flanges require flat stone slabs to bridge them, in order to provide a bearing for the brickwork above, but in the second case the space between the beams is filled with cement concrete which is deposited upon a course of tiles laid flat across the bottom flanges. Thus, the interior is thoroughly protected from oxidation. When cement concrete is to be so used the surface of the metal to be in contact is better left unpainted, but it is common practice to paint all the surface of the lintols so employed at least once before use.

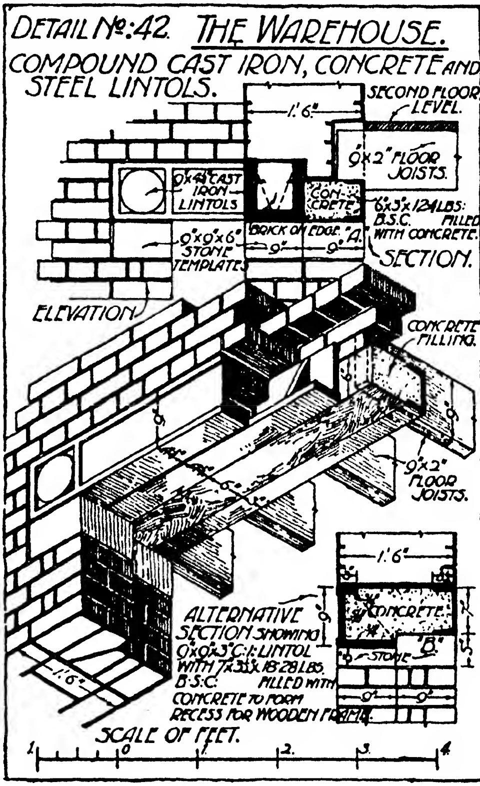


126. Reinforced concrete lintols. Reinforced concrete lintols may be either *cast in situ*, or *precast* and set like a wood, stone, or steel lintol.

The illustration shows the arrangement of the reinforcement suitable for casting *in situ*. If precast, one or more light rods should be placed near the top of the beam and parallel to the top surface. This is a precaution to avoid fracture of the lintol in the event of its being turned over accidentally in handling and lifted by its ends; and also to allow of its being slung for lifting at its centre.

In detail No. 41 the reinforced concrete lintol is used as a backing

to a stone lintol. Where plain brick walls are adopted, the concrete lintol might be cast the full thickness of the wall and be allowed to show on the face, or, it might be faced with bricks on end, set vertically. The reinforcement may be of $\frac{1}{4}''$ to $\frac{1}{2}''$ diameter round steel rods, or of barbed steel wire, which in ordinary cases are placed $1\frac{1}{2}''$ from the bottom surface of the lintol, but, where several of these rods occur, some may be advantageously bent upwards as shown in detail No. 41. Over short spans of 3′ 0″ or less, the rods may be placed horizontally, or, in many cases may be omitted.



Applications of this form of lintol in the house and warehouse have been shown in many details. Small tee bars may also be employed as an alternative reinforcement. Detail No. 32 shows the lintol prepared with a rebate to receive the concrete slab of the ground floor of the warehouse, this being necessary to allow the basement window openings to be as high as possible; two reinforcing bars are placed immediately below the rebate to provide resistance to the floor load transmitted by the slab.

127. Compound lintols. Lintols are often compounded of two or more materials as previously illustrated in Vol. I and in the foregoing paragraphs. The use of reinforced concrete for lintols, or of cast iron and steel sections with concrete filling, will often facilitate the solution of practical difficulties of support, because it is possible to place these in different relation to each other to suit the levels of floors and door or window openings.

The upper floor windows of the back and side elevations of the

warehouse are spanned by sunk panelled cast iron lintols over the front reveal and B.S.C.'s placed flush on the inside. The space between is filled with concrete. Both pieces of the front lintols are cast to the same sunk pattern, this being an advantage in the case of the first floor windows as it assists the concrete backing to resist vibration of the floor and thus avoids a loose vertical joint between the concrete and cast iron.

If prepared for the reception of iron window frames a level soffit is required as shown at A in detail No. 42 where a B.S.C. 6″ × 3″ × 14·5 lbs. is placed on edge and the joists of the second floor are notched over it and carried 4½″ into the wall. If a recess is required for wooden frames as at B in the detail, a B.S.C. 7″ × 3½″ × 20·23 lbs. may be used in conjunction with the 9″ × 9″ cast iron lintol, thus giving a level top and a 2″ recess in the soffit. Such a lintol is applied to the top floor windows of the warehouse.

Another arrangement of this form of lintol is shown in detail No. 33 where the depth between the underside of the floor joists and the soffit of the lintol is only 4″. To meet this condition a B.S.C. 8″ × 4″ × 25·7 lbs. is laid flat, filled flush with concrete and thus forms a level bearing for the joists.

CHAPTER SEVEN

STRUCTURAL IRON AND STEEL WORK

Steel Framed and Fire-Resisting Floors

128. Before entering upon the detailed consideration of fire-resisting floors a brief reference will be made to the principles of general construction intended to offer resistance to the action of fire.

It must be borne in mind that, while a structure may itself be an assemblage of incombustible materials, it may house very combustible materials in the shape of stores, fittings and furniture, which, on ignition, may expose much of the structure to high and variable temperatures for some hours. The length of exposure will depend upon the nature and quantity of the contents and also upon the provision for extinguishing the flames.

No structure is really fire-*proof*, but most modern structures of any importance can claim to be fire-*resisting*.

129. Fire-resisting structure. Fire-resisting structures are those constructed of incombustible materials, so arranged that if exposed to the action of fire they may suffer a minimum of damage. Successful fire-resisting construction will not collapse if exposed to a high temperature for two or three hours.

Most structures would be visibly damaged by a prolonged fire, especially when suddenly quenched, because the expansion caused by the rise in temperature is suddenly arrested and a quick contraction takes place, tending to disintegrate such granular materials as stone, brick and concrete, which may partially decompose with the effect of heat.

The greatest danger, however, is caused by the large expansion of the steel[1] which, if held in position by bolts and rivets or by close fitting between adjacent and weighty portions of the structure, develops stress in opposition to their fixity. Owing to the variations in temperature of the heated members, some portions expand more than others with the result that they are strained and if the action continues they are twisted out of their original form, and where two or more pieces of steel are fixed together they become mutually destructive and collapse is frequently caused.

The effects upon brick, terra-cotta and suitably prepared portland cement concrete are not serious[1] because they conduct heat slowly

[1] See Chapter on Materials.

and their expansion is consequently slower, but steel employed with them for purposes of support soon becomes hot if directly exposed, hence, in a structure presumed to be fire-resisting all steel work must be sufficiently clothed with slow heat-conducting material to prevent the temperature rising to a dangerous point within the period reasonably demanded for extinguishing the flames.

Cast iron is much like steel and wrought iron in the degree of expansion and rapidity of heat conduction, but because of its granular structure does not twist into the fantastic shapes so often taken by steel members during a fire. It is liable to collapse owing to its brittleness and when quenched is very liable to snap or fly to pieces because of the sudden and unequal contraction. Cast iron is still in use in some districts for columns supporting floors and if adopted for important fire-resisting construction should be protected against the heat by similar methods to those employed for steel stanchions and beams.

130. Degree of fire-resistance in floors. In the following paragraphs no attempt is made to classify the floors illustrated and described with regard to their fire-resisting qualities.

Some of the constructions are included as elementary examples of the method of employing steel and concrete in floors and are fire-resisting in virtue of the materials employed, although the primary reason for employing them may be merely to obtain a concrete surface for sanitary purposes or to receive a special tile finish as in the case of the entrance hall to the house and the lavatory floors to the warehouse. Thus, while the latter serves an obvious purpose in being fire-resisting, because the whole structure is more or less of that character, the former makes no such claim, being only a convenient form of construction in an otherwise simply constructed house with timber floors.

The foregoing note will, however, assist the student to appreciate the fire-resisting value of the construction under consideration and to recognise its more extended application to different structures under suitable conditions.

131. Use of steel in modern floor construction. There are two general methods of employing steel in the construction of floors. The more generally applied method is to erect a framing of horizontal steel members upon or within which are supported panels of concrete, brick or terra-cotta tiles or precast units of tubular form. In another method the steel is distributed in small sections throughout masses of concrete for the purpose of resisting tensile stresses and reinforcing the concrete where it is necessary; this constitutes what is known as "ferro-concrete" or "reinforced concrete".

The primary purpose at present is to study the steel framing and panelled fillings of typical systems of construction and to leave "reinforced concrete" for later study, although simple examples are given of the use of reinforcement in the slabs of concrete and the lintols employed for floor panels without entering into the theoretical principles involved.

132. Terms employed in steel floor construction.

Joists are the small steel beams carrying the floor slab and may be of ⊥, I or ⊐ section. They are usually spaced at 1′ 6″ to 3′ 0″ centres and may be entirely enclosed by concrete or placed beneath it according to the depth available. They are also termed "filling joists" or "fillers".

Girders are large beams supporting joists, or directly supporting the structure of large panels in patent floors.

There are commonly two sets of girders in a large floor, one series being supported by the other. The dependent girders are known as *secondary* girders or "secondary beams", and those transmitting the load from the ends of the secondary girders to the supporting walls or pillars are termed *main* girders or "main beams".

Floor panels or *bays* are the spaces bridged by the joists, slabs or filling and bounded in plan by girders.

Floor slab; the mass of concrete or other material, 3½″ or more in thickness, upon which the wearing surface of the floor is laid.

Floor lintols; special beams of fireclay or concrete and usually hollow, employed as single or compound units to bridge the span of a floor panel or the space between pairs of joists.

133. Steel sections used in floor construction. The British Standard forms of rolled steel section intended for structural purposes have already been referred to, and selections of these are included in Vol. I. Of the standard forms the **I** section is most economical and suitable for beams and is obtainable in many sizes between 3″ × 1½″ and 24″ × 7½″ as shown in the appendix.

The horizontal plates or tables of **I** or ⊐ beams are called "flanges", their function being to resist the deflection of the beam by developing tensional and compressional stresses, while the vertical member, or "web", transfers these stresses to the flanges and struts them apart.

See Vol. III for full consideration of the forms and properties of structural steel sections. The principles for determining the loads to be safely carried by floor beams and the method of selecting suitable sections for known conditions of loading are also given in Vol. III.

The present purpose is to show how these sections are utilised in

floor construction and how the members are assembled and secured in good practice.

134. Plain steel and concrete floors. The oldest and still common method of arranging these floors is to place steel joists parallel to each other at 1′ 6″ or more centre to centre, to support the joists on walls or cross girders and to fill between and around the joists with concrete which is temporarily supported by wooden platforms or shuttering. When the concrete is sufficiently set the shuttering is removed and the concrete between the pairs of joists acts as a wide short beam supported by them.

Plain concrete slabs must be 5″ thick to be accepted as fire-resisting in the London County Council area. It is not usually possible to adopt a less thickness than 5″ if the joists are to be covered on their soffits to the depth of 1″ which is the minimum allowed.

Apart from the question of fire-resistance, the thickness of floor slabs and the dimensions of the joists will vary mainly with the load per foot super which the floor is intended to support, and also upon the quality and nature of the materials employed.

Steel and concrete construction is applied in the lavatory and landing floors of the warehouse and in the floor of the entrance hall to the house.

Alternative methods are shown in each case.

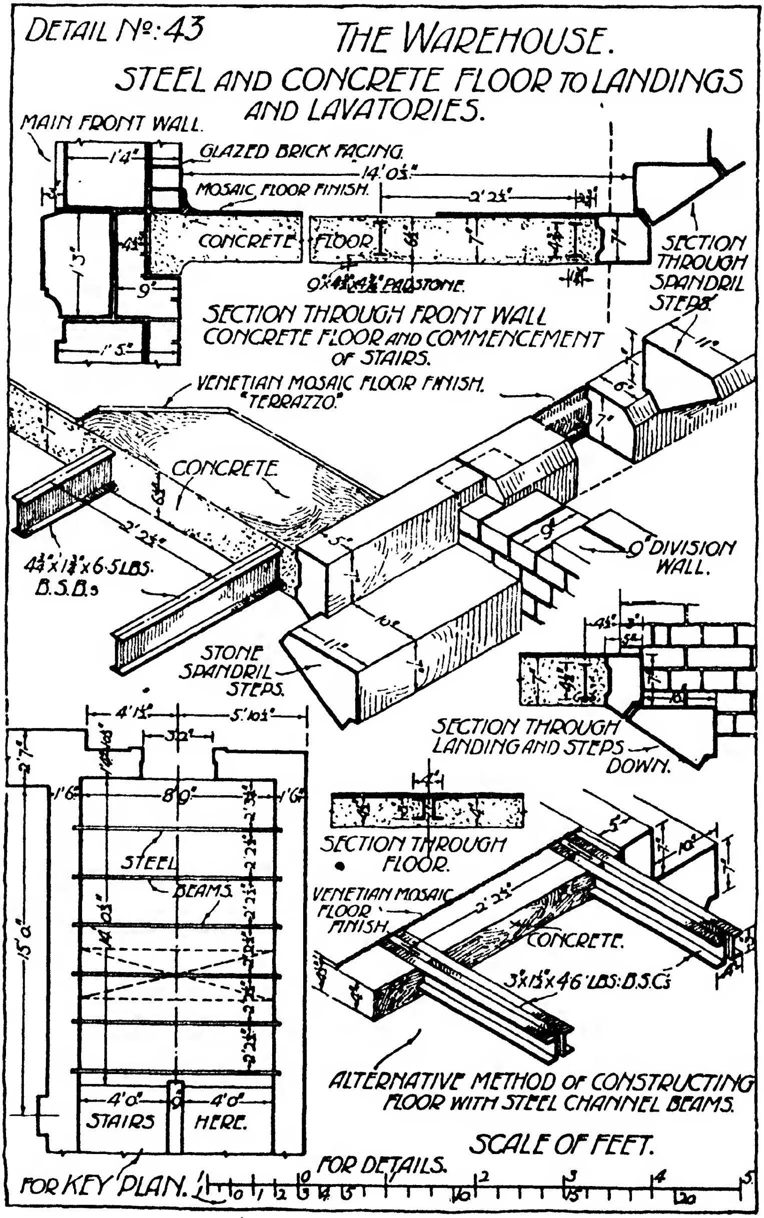
135. Floors to landings and lavatories of warehouse.

(*a*) *With British Standard Beams.* Detail No. 43 shows that the space to be bridged between the external and staircase walls is about 13′ 6″ × 8′ 9″. Using B.S.B.'s, 4¾″ × 1¾″ × 6·5 lbs. per ft. and spacing at 2′ 2½″ centres a satisfactory arrangement of joists is obtained as shown by the calculations.[1] These joists extend 4½″ upon each wall and rest upon 9″ × 4½″ padstones 4¾″ thick, this odd size being necessary to level up to the brick courses as shown in the detail, where the thickness and disposition of the concrete in the floor slab is also shown.

(*b*) *With British Standard Channels.* An alternative construction is shown in the lower part of the same detail, where each joist consists of two B.S.C.'s 3″ × 1½″ × 4·6 lbs. per ft., these being riveted together at about 1′ 6″ centres and packed 1″ apart by metal discs or plates between the channels.

This method employs more steel but allows a thinner concrete slab to be adopted. The space between the channels allows of the insertion of ordinary ¾″ bolts from which the shuttering can be suspended, thus avoiding the use of special dogs or hangers which are necessary for **I** beams, as shown in Vol. III.

[1] See Vol. III.


DETAIL No: 43
THE WAREHOUSE.
STEEL AND CONCRETE FLOOR TO LANDINGS AND LAVATORIES.
MAIN FRONT WALL.
GLAZED BRICK FACING.
MOSAIC FLOOR FINISH.
CONCRETE FLOOR
9"x4½"x4½" PADSTONE.
SECTION THROUGH FRONT WALL CONCRETE FLOOR AND COMMENCEMENT OF STAIRS.
SECTION THROUGH SPANDRIL STEPS.
VENETIAN MOSAIC FLOOR FINISH. "TERRAZZO."
CONCRETE
4¾"x1¾"x6.5LBS. B.S.B.s
9" DIVISION WALL.
STONE SPANDRIL STEPS.
SECTION THROUGH LANDING AND STEPS DOWN.
STEEL BEAMS.
STAIRS HERE.
SECTION THROUGH FLOOR.
VENETIAN MOSAIC FLOOR FINISH.
CONCRETE.
3"x1½"x4.6 LBS: B.S.C.s
ALTERNATIVE METHOD OF CONSTRUCTING FLOOR WITH STEEL CHANNEL BEAMS.
SCALE OF FEET.
FOR KEY PLAN.
FOR DETAILS.

This floor is also very convenient where loads have to be suspended from a ceiling, *e.g.* light shafting, suspension bolts for run ways, etc.; the additional effect of these loads must of course be allowed for in the design and selection of the joists.

In ordinary cases the spaces between the channels would be filled up with concrete, though in some instances they are left open for subsequent use in suspending loads, the gap being merely closed from view by ceiling plaster and flooring.

136. Concreting of floors. The preparation of concrete for floors is dealt with in detail in the Chapter on Materials, Vol. III, but a short note here will be useful.

The concrete employed should be a light, yet strong mixture of portland cement, sand and coarse material in the ratio of $1+2+4$ parts by volume, in the order named. This is the minimum quality and the strength may be increased by increasing the ratio of cement.

A wooden platform or shuttering is prepared in position below the joists, and the concrete deposited thereon, and left undisturbed for a period of 7 to 14 days. It should then be sound enough to support the weight of workmen though it is wise to prohibit the application of any load until 28 days old unless rapid hardening cement is used.

137. Concrete filling and finish to lavatory floors. Detail No. 43 shows the concrete floor filling for the alternative methods of construction. In the first example the concrete is $6\frac{1}{2}''$ thick and completely encases the joists, with a cover of 1″ below their soffits. To retain this covering concrete in position, a strip of wire-net or expanded metal lathing, 5″ or 6″ wide, is bent round the lower flange of each joist and becomes suspended therefrom; a clear space should exist between the lathing and the joist to afford a key for the concrete and at the same time the metal should be covered by $\frac{3}{8}''$ or $\frac{1}{2}''$ of material. On laying the concrete, fine material is first rammed underneath the joist from each side, so filling the space between joist and shuttering, and the remainder of the span between the joists filled and screeded to the required level with ordinary concrete.

In the alternative method of construction, the concrete is finished level with the top of the channel joists, which, with the 1″ soffit covering, makes a floor 4″ thick.

These floors might be finished with a $\frac{1}{2}''$ screeding of cement mortar, or with suitable plain tiles, or with Venetian mosaic.

138. Venetian mosaic floor. This floor finish is applied by first floating up the concrete with a $\frac{1}{2}''$ coating of cement mortar which is mixed with marble or other suitable chippings of any shape and

colour, small enough to pass a $\frac{3}{8}''$ square mesh. The coat is screeded level, well consolidated and polished after setting by grinding the surface with a weighted grit stone and rubbing to a fine finish with sand and water. The object is to expose small polished faces of the chippings, thus producing a variegated plane surface which can readily be cleaned.

Electrical appliances are also in common use for grinding and polishing these and similar hard-finished floors.

The above described type of finish is known as "Venetian mosaic" or "Terrazzo" and its application is shown in detail No. 43 where it is continued up the side walls to a depth of 3″ and coved at the angle to form a skirting.

Patterns may be arranged by embedding wood templets in the floating coat, removing these when the first filling is set and making up the recesses with a mixture of a different colour.

139. Hall floor to house. This floor has a much larger span than those considered in the previous paragraphs, hence, while the same general method of construction with joists and concrete is employed, the joists receive support from steel girders. The dimensions of the floor between walls are 21 ft. long × 14 ft. $10\frac{1}{2}$ ins. wide, and the disposition of girders and joists to provide an opening for the basement stair is given by the key plan of detail No. 44.

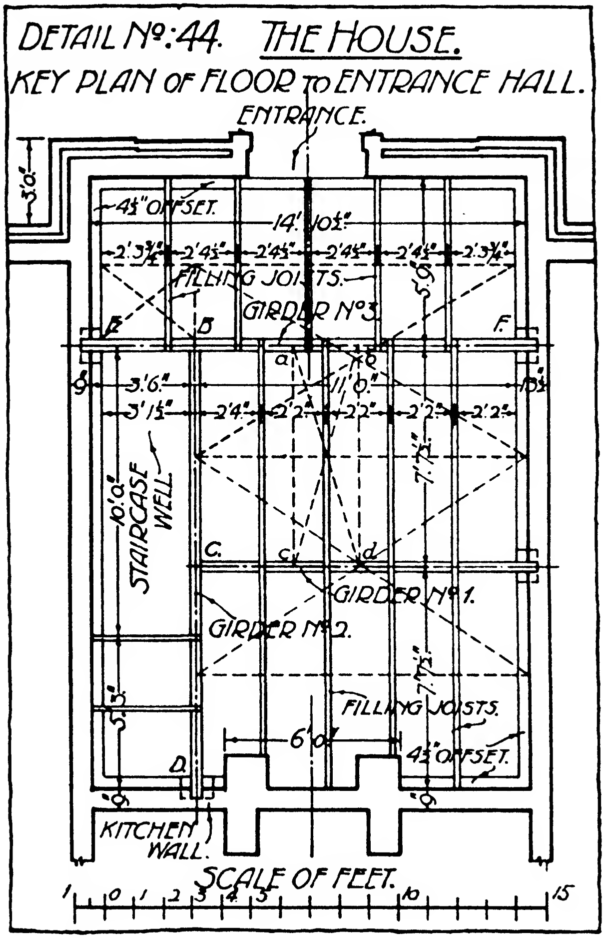
The stair opening measures approximately 10 ft. × 3 ft. 6 ins. and its position determines the situation of girder No. 3, which is placed as close as possible to the stairway. The trimming girder, No. 2, forms the side of the opening parallel to the wall.

140. Main steel members to hall floor of house. In the absence of a stair opening this floor would have been treated as an ordinary double floor with binders across the short span supporting the floor joists. To form the opening described in the last paragraph the girders or main beams are arranged to give adequate and economical support to the joists while leaving the necessary space for the stair as follows:

The girder, No. 3, is placed across the short span EF at a distance of 5′ 9″ from the front wall to the centre of the beam and is a B.S.B. 8″ × 5″ × 28 lbs., 15′ $7\frac{1}{2}''$ long; it is supported by the cross walls forming the two sides of the basement. The side of the opening is bounded by girder No. 2, which is a beam of the same section, also 15′ $7\frac{1}{2}''$ long, extending from the main beam at B to the back basement wall at D. A third girder (No. 1) is either a B.S.B. 7″ × 4″ × 16 lbs., 11′ 9″ long—which is rather light—or a B.S.B. 8″ × 4″ × 18 lbs. which would make the girders of uniform depth. This girder is placed parallel to girder No. 3 dividing the space

between the latter and the kitchen wall into two equal bays; it is supported at one end on girder No. 2 at C.

141. Bearings. All beams having a span exceeding 10 ft. should have bearing surfaces at least 9″ long. In the example these are



provided by stone templates $13\frac{1}{2}'' \times 9'' \times 3\frac{1}{2}''$ thick, with felt, millboard or lead pads between the beam and template. These latter minimise the effect of irregularities on the steel and stone surfaces, and thus ensure a more uniform distribution of the load; they are important for heavy loading.

142. Joists to hall floor of house. The joists employed here are B.S.B.'s 4″ × 1¾″ × 5 lbs. per ft. and may be arranged in two ways:

(*a*) They may rest upon the top flanges of the steel beams, being supported directly and *only* thereby, as illustrated in the upper part of detail No. 45.

(*b*) They may be placed slightly below the top flanges and cut to fit between the webs of the beams, being jointed thereto by steel angles and rivets, as shown in the lower part of the detail.

The first may be adopted where the loss of height in the room below the floor is of no consequence and the second for cases where a shallow floor is desirable, as much of the girders as possible being encased within the depth of the floor.

The joists are spaced at from 2′ 2″ to 2′ 4½″ centres, though this may be varied, provided the joists are of the correct strength and the concrete of adequate thickness.

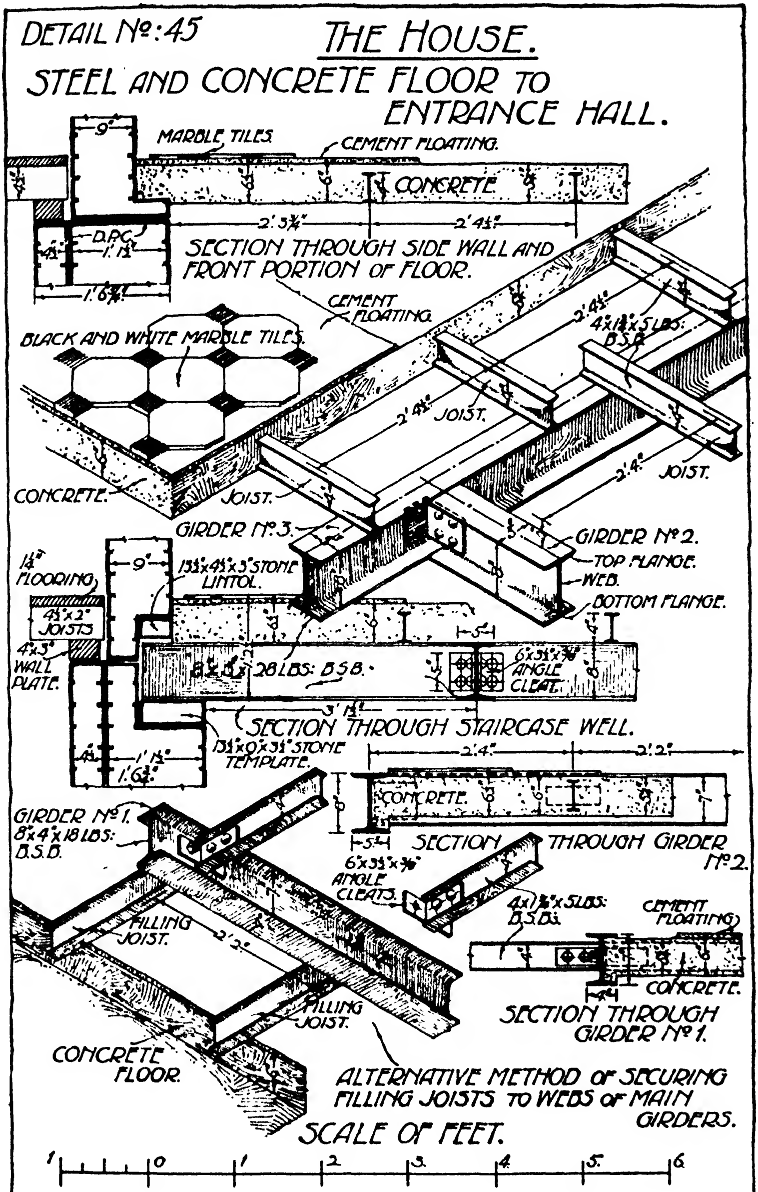
143. Concrete floor with exposed beams, entrance hall of house. An examination of the two sections given on detail No. 45 will show that the concrete is 5¼″ thick being level on the underside with the soffit of the joists and rising 1¼″ above them. The steelwork of the main beams and soffits of the joists would therefore be exposed to view and must be protected by painting.

If the position is of sufficient importance to require a better finish the underside of the concrete may be plastered and the joists, being narrow, would not appreciably interfere with the key of the plaster; if portland cement plaster is employed it would adhere to the joists satisfactorily provided they were not painted. If new joists are washed over with portland cement and water in the form of a very thin grout the adhesion is much improved, but all scale and loose rust should be removed before applying the wash.

144. Concrete floor with sides of girders encased. Detail No. 45 shows the alternative floor, where the main beams are enclosed within the depth of the floor to the maximum extent. The concrete enclosing the joists is 6″ thick, rising to a level of ½″ above the top flanges of the main beams and enclosing the bottom flanges of the joists by a ¾″ covering.

In this case the recessed sides of the beams are filled with fine concrete forming a "haunch" upon which the floor concrete is supported between the joists. Only the edges and soffit of the bottom flanges are exposed to view; these require painting for protection.

145. Marble tile floor to hall of house. The concrete floor is prepared to receive the covering by first floating with cement and sand, 1 to 2, about ½″ thick. When set, a further thin coat of a slightly richer mortar is laid and ½″ thick marble tiles are bedded


DETAIL No: 45
THE HOUSE.
STEEL AND CONCRETE FLOOR TO ENTRANCE HALL.
MARBLE TILES
CEMENT FLOATING.
CONCRETE
SECTION THROUGH SIDE WALL AND FRONT PORTION OF FLOOR.
CEMENT FLOATING
BLACK AND WHITE MARBLE TILES.
4"x1¾"x5 LBS: B.S.B.
JOIST.
CONCRETE.
GIRDER No 3.
GIRDER No 2.
TOP FLANGE.
WEB.
BOTTOM FLANGE.
1¼" FLOORING
4½"x2" JOISTS
4"x3" WALL PLATE.
13½"x4½"x3" STONE LINTOL.
8"x5"x28 LBS: B.S.B.
6"x3½"x⅜" ANGLE CLEAT.
SECTION THROUGH STAIRCASE WELL.
13½"x9"x3½" STONE TEMPLATE.
GIRDER No 1. 8"x4"x18 LBS: B.S.B.
CONCRETE.
SECTION THROUGH GIRDER No 2.
6"x3½"x⅜" ANGLE CLEATS.
4"x1¾"x5 LBS: B.S.B.
CEMENT FLOATING
CONCRETE.
SECTION THROUGH GIRDER No 1.
FILLING JOIST.
CONCRETE FLOOR.
ALTERNATIVE METHOD OF SECURING FILLING JOISTS TO WEBS OF MAIN GIRDERS.
SCALE OF FEET.
1 0 1 2 3 4 5 6

thereon, the vertical joints being finely made with Keene's cement.[1] The tiles may be of any pattern and colour and in the example illustrated at detail No. 45 large white octagons are alternated with small black squares which, with a black and white border, complete the scheme.

Great care must be taken in laying the tiles to avoid irregular setting and also to prevent discoloration of the more delicate tints of the lighter marbles.

When complete and set the floor may be polished as described in the Chapter on Materials.

Beams and Joist Connections

146. Connections of beams. Two kinds of beam connection occur in the hall floor. The enlarged detail, No. 46, shows the joint between two beams of equal size, viz. $8'' \times 5'' \times 28$ lbs.; in this case, the top and bottom flanges of the stopped beam are cut back, leaving the web to project and fill the space between the flanges and web of the continuous one. The purpose in view is to make a connection between the two webs, which is done by placing a short length of steel angle on each side, riveting the pair to the web of the stopped beam during preparation and then bolting the wings to the main beam for final assembly.

Short pieces of standard angle are commonly employed for all kinds of connections and are known as "cleats". For joining British Standard Beams each steel firm has established its own standard size of cleat for every beam in regular use; for the present, students should take care to select both standard sections and standardised connections, obtaining the latter by reference to manufacturers' lists.

Referring again to the connection of the two $8'' \times 5''$ beams in detail No. 46, it will be seen that the cleat is a piece of B.S.U.A., $6'' \times 3\frac{1}{2}'' \times \frac{3}{8}'' \times 11{\cdot}64$ lbs. per ft. and 5″ long, having four $\frac{13}{16}''$ holes for $\frac{3}{4}''$ *rivets* in the long arm attaching to the stopped girder and two $\frac{13}{16}''$ holes for $\frac{3}{4}''$ *bolts* in the short arm. The position of these holes is stated by the back gauge, margin and pitch, which are shown on the detail.

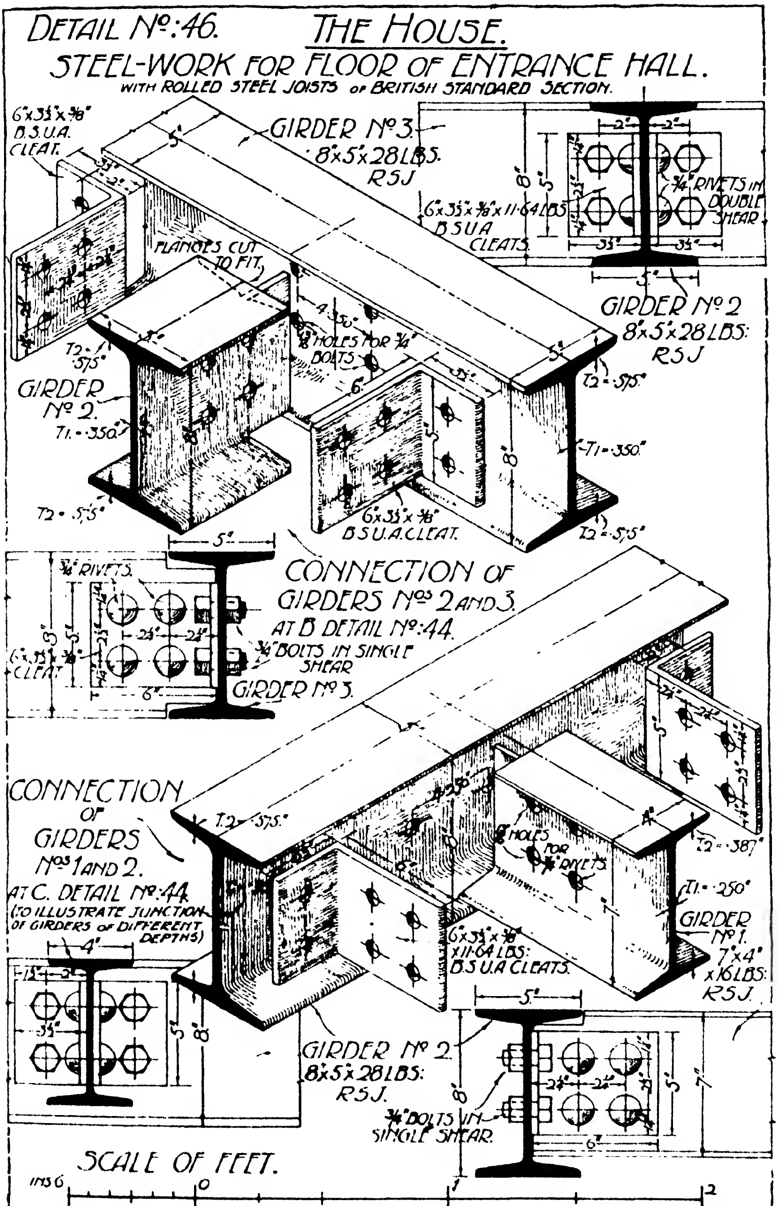
Back gauge is the distance of the centre line of a rivet or bolt hole from the back edge of an angle cleat or channel.

Pitch is the longitudinal distance between the centres of bolt or rivet holes.

Margin is the distance from the centre of the outer holes to the edge of the section and should be at least $1\frac{1}{2}$ times the diameter of the bolt or rivet.

Another junction occurs at C in detail No. 44, and is shown enlarged in the lower part of detail No. 46. The beams to be

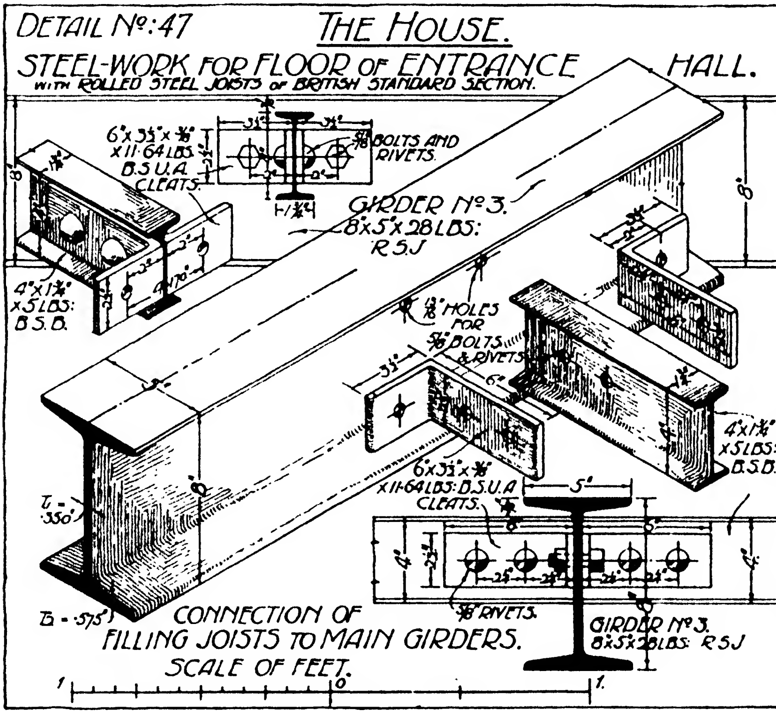
[1] See Chapter on Materials.


DETAIL No:46. THE HOUSE.
STEEL-WORK FOR FLOOR OF ENTRANCE HALL.
WITH ROLLED STEEL JOISTS OF BRITISH STANDARD SECTION.
6"x3½"x⅜" B.S.U.A. CLEAT.
GIRDER No3. 8"x5"x28LBS. RSJ
6"x3½"x⅜"x11·64LBS B.S.U.A CLEATS.
¾" RIVETS IN DOUBLE SHEAR
GIRDER No2 8"x5"x28LBS: RSJ
FLANGES CUT TO FIT.
⅞" HOLES FOR ¾" BOLTS
GIRDER No 2.
6"x3½"x⅜" B.S.U.A.CLEAT.
CONNECTION OF GIRDERS Nos 2 AND 3. AT B DETAIL No:44.
¾" RIVETS.
¾" BOLTS IN SINGLE SHEAR
GIRDER No 3.
CONNECTION OF GIRDERS Nos 1 AND 2. AT C. DETAIL No:44. (TO ILLUSTRATE JUNCTION OF GIRDERS OF DIFFERENT DEPTHS)
⅞" HOLES FOR ¾" RIVETS
6"x3½"x⅜" x11·64 LBS: B.S.U.A CLEATS.
GIRDER No1. 7"x4" x16LBS: RSJ.
GIRDER No 2. 8"x5"x28LBS: RSJ.
¾" BOLTS IN SINGLE SHEAR.
SCALE OF FEET.
INS 6 0 1 2

connected have been assumed as 8″ × 5″ and 7″ × 4″, having their top flanges on one level to receive the joists. This assumption is made in order to show how to connect beams of different depths.

In this instance the top flange only is removed and the web and bottom flange of the smaller beam abut against the web of the larger one.

Angle-cleat connections are used as in the previous example with the necessary rivets and bolts to secure them.



147. Connections between joists and beams. When a joist is to be connected to a beam the form of the joint depends upon their relative positions. The joist may merely rest loosely upon the top of the beam, or, in special cases, may be bolted thereto through the adjoining flanges.

If the joist must be kept below the flange of the girder, and is shallow enough to pass between the two flanges, it is cut off square, butted against the web of the beam and connected by a pair of angle cleats in the manner described in paragraph 146 and further illustrated at detail No. 47. The cleats are of some standard size, *e.g.*

$6'' \times 3\frac{1}{2}'' \times \frac{3}{8}''$ B.S.U.A.'s $2\frac{1}{2}''$ long, and fixed by $\frac{5}{8}''$ rivets to the webs of the $4'' \times 1\frac{3}{4}''$ joists and by two $\frac{5}{8}''$ bolts to the webs of the beams.

148. Bolts and rivets. Bolts have already been described and specially illustrated in Vol. I.

Rivets are pins of wrought iron or steel having a plain shank, and a head which is generally of spherical outline. The shank is slightly tapered over part of the length to facilitate placing in position. Rivets are heated to a cherry red along the shank, placed through the metal parts to be assembled and "clenched", that is, hammered on the hot point and made to overlap the surface of the plate. During the process of clenching the shank of the rivet is swollen in diameter and thus made to expand and fill the hole in somewhat imperfect fashion, being usually tight near the newly clenched point but not so good near the head. The rivet end is usually finished to the same shape as the original head, by striking with a tool of the reverse form, so that when finished, both ends are practically alike and may be spoken of as rivet heads.

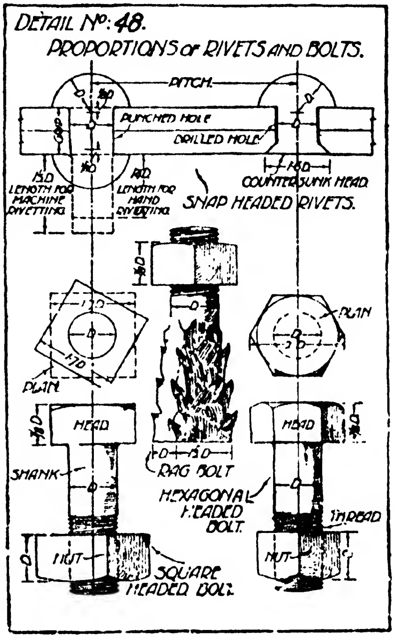
149. Grip of rivets. Because metal expands considerably with an increase of temperature and contracts similarly with a decrease, holes to receive rivets must be large enough to admit them freely when hot. As the rivets cool during and after clenching, they tend to become shorter in length and do so until arrested by the plates, when they become stressed in tension by their effort to shorten; thus a strong "grip" exists, causing pressure between the plates.

At the same time the cooling rivet decreases in diameter and, although it may have filled the hole more or less perfectly when hammering ceased, there is possibly some little slackness of fit when quite cold. The grip of the rivet heads upon the plates is usually sufficient to prevent movement of the parts when loaded, though its effect is neglected in calculations—being indeterminable. Close contact of the rivet shank with the sides of the hole is assumed.

150. Selection of bolts and rivets. When deciding the use of bolts or rivets for any connection, the conditions of the case must be considered with regard to strength and practical convenience.

Rivets are much more reliable and produce firmer connections; they should always be employed where convenient, which generally means that all joints which may be completed before delivery on the site are riveted. For those joints which must be made on the site while assembling parts of the structure, bolts are more often employed for the smaller jobs, but there is now a disposition to insist on rivets, which can easily be employed in straightforward jointing by the use of portable riveting machines. Rivets which are clenched in the works are known as "shop" rivets; those clenched on the site are called "field" rivets.

Where bolts are employed they must be of the standard proportions previously referred to and also shown in detail No. 48, with solid forged heads and of a length to pass completely through the thickness of the nut, which is $\frac{7}{8}$ of the diameter of the shank. To prevent nuts working loose under possible vibratory loads, they should be screwed perfectly tight to give adequate grip between the plates and then locked to prevent movement. The usual method is slightly to rivet the end of the bolt over the nut.



151. Sizes of bolts and rivets. Bolts and rivets are both described by the diameters of their shanks, and by the lengths of the shanks measured from beneath the heads.

The length of a rivet must be the combined thickness of the plates or other parts to be assembled plus the necessary length for forming the head, such length varying with the shape of the head and also whether the rivet is to be clenched by hand or by machine.

The diameters of rivets in building construction are generally $\frac{5}{8}''$, $\frac{3}{4}''$ or in special cases $\frac{7}{8}''$, $\frac{3}{4}''$ being the most suitable for average work. It is possible to determine the theoretically economical diameter for any given case, but true economy depends largely on practical convenience in saving labour costs, hence the adoption of the $\frac{3}{4}''$ rivet except where difficulties of clenching or lack of strength intervene.

152. Rivet heads. Rivet heads are usually of part spherical form and known as "cup" or "snap" heads, and when clenched the projecting ends are hammered or forced down to a similar cup shape, except in cases where a flat surface is necessary, as required for the bearing ends of beams.

Both forms are shown fully in detail No. 48 which gives British standard proportions.

The flush head is obtained by forming a conical depression round the hole, hammering the end down into it and finishing flush by

chipping and filing off superfluous metal. Such heads are said to be *countersunk*, a method commonly practised with wood screws.

To form a snap head on a $\frac{3}{4}''$ rivet by a machine needs an excess length of $1\frac{3}{8}''$ to $1\frac{1}{2}''$, while for hand riveting the excess required is $1\frac{1}{8}''$ to $1\frac{1}{4}''$. Machine riveting fills the holes better, gives a more compact and well finished head and a tighter grip on the plates to be joined.

153. Holes for bolts and rivets. Holes to receive bolts or rivets may be either drilled or punched if of small diameter and through thin plates. The larger holes are usually drilled.

Drilling is the process of removal by a rotary cutting tool which results in a clean, sharp edged cylindrical hole; the process does not damage the metal plate, but is slower and costlier than punching, except perhaps where groups of holes can be drilled in one operation by a battery of drills.

Punching consists of forcing a hole through the plate by steady pressure applied to a hard steel pin or punch, which *shears* a small cylinder of metal through the plate in one piece. Punching is a rapid process, but not satisfactory for the more important work, because the hole is rounded on the edge where the punch entered and burred or raised on the opposite edge, showing that the fibres round the hole have been dragged downwards and damaged. The hole is really slightly tapered which is an advantage if two holed plates are brought together with the smaller diameters in contact; the clenched rivet is then slightly dovetailed and grips well if properly driven. All punched holes should have the burred edge removed before assembling, except in temporary work.

154. Function of bolts and rivets in connections. In all connections of joists or beams, web to web, the chief function of the rivets is to oppose the tendency to sever the connection, caused by the load acting vertically upon the joint. Consider a secondary beam jointed to a main beam; the former receives load from the joists and flooring which it supports and transmits the load to the latter through the riveted or bolted joint.

The rivets through the web of the secondary beam tend to cut through in two planes, viz. the vertical planes of junction between the web and the angles. The bolts through the angles and web of the main beam are also subject to a similar tendency but acting vertically through the single plane of junction between angles and web for the connection of one beam. When the tendency to cut is on one plane only the pins are said to be in *single shear*, while *two* such cutting planes at one joint, acted upon simultaneously, constitute a *double shear*.

While the rivets and bolts resist shear, they also have to resist

crushing at their circumferences where the pins and holes are in contact. This local compression is called *bearing* and must be resisted both by the pin and the material surrounding the hole in the connected member.

155. Strength of steel rivets. Rivet steel of standard[1] quality will safely bear a shear stress of 6 tons per sq. inch of sectional area, and a bearing stress of twice this amount, viz. 12 tons.

From the above reference to single and double shear, it would appear that a rivet subject to double shear under the same loading as one under single shear, would be of twice the strength. Theoretically, this is the case, *and is accepted in the new Code of Practice.* Owing to holes not being in perfect line or rivets being improperly clenched and also because the load might be imperfectly distributed across the two planes, it has been usual in the past to credit the rivet with $1\frac{3}{4}$ times the strength instead of double.

156. Strength of bolts. Bolts must as a rule, fit easily through the parts of a structure which they are employed to connect, in order to get them into position without damaging their threads; they are not quite so reliable as rivets even though they are turned and close fitting and of high quality metal.

There are two reasons for this; first, the same grip between the parts cannot be obtained without damaging the threads; second, shear and bearing stresses only act upon the shank either after a slight movement of the parts to force loose fitting bolts into working contact, or accidentally upon such bolts as happen to be in contact. For this reason it is usual in good designs to reduce the working stresses upon loose fitting and inferior bolts.

The new Code of Practice allows:

For parts in shear.

On shop rivets and tight-fitting turned bolts	6 tons per sq. in.	Quality A steel
On field rivets	5 ,, ,, ,,	
On *black bolts* (where permitted to be used)	4 ,, ,, ,,	

For parts in bearing.

On shop rivets and tight-fitting turned bolts	12 tons per sq. in.	Quality A steel
On field rivets	10 ,, ,, ,,	
On *black bolts* (where permitted to be used)	8 ,, ,, ,,	

[1] These values refer only to structural steel of Quality A complying with B.S.S. No. 15, and are adopted in the new Code of Practice.

157. Rag bolts. In the centre of detail No. 48 is shown a rag bolt, which is employed for securing metal construction to stone or concrete work.

The most common use is to secure the steel shoes of roof trusses to stone templates.

The shank of the bolt is expanded to a dovetail form with sharply serrated angles, and would be fitted into a dovetailed mortice in a stone, which is filled with lead and caulked, or may be built into concrete. For the latter purpose the shank would need to be much longer than shown; it is also common to build in long ordinary bolts, with bearing plates, for similar purposes. See Vol. III.

158. Lewis bolts are similar in form to rag bolts but have either plain dovetail ends, or indented faces formed while hot by making diagonal depressions with a sharp tool. They are not so efficient as rag bolts.

CHAPTER EIGHT

STRUCTURAL IRON AND STEEL WORK

Roofs

159. Steel roof trusses. Modern roof trusses are very commonly constructed of steel members secured at their junctions by rivets (or occasionally bolts) passed through jointing plates or gussets of steel upon which the members are assembled.

Steel trusses have many advantages over wooden roof trusses, the more important of which are:

(*a*) Members carrying the same load may be much smaller in dimensions than in wooden trusses, the reduction giving a less weighty appearance and at the same time interfering less with the passage of natural light where skylights are required.

(*b*) Large spans may be bridged quite easily, which would be beyond the economical capacity of timber except where very light coverings of a semi-temporary nature are to be used and arched trusses employed.

(*c*) The members may be arranged in a much more scientific and satisfactory manner than those of timber trusses, because the centre line principle can be very generally carried out in assembling the members.

(*d*) The material is much more dependable than timber in character and quality.

On the other hand steel roof trusses have disadvantages of which we may usefully mention that:

(*a*) They lack transverse rigidity which, however, can be remedied by the correct disposition of purlins, etc.

(*b*) Maintenance is not economical as compared with timber, painting being periodically necessary to prevent oxidation of the metal.

(*c*) Satisfactory architectural treatment is often very difficult, and for this reason timber may be selected as the correct material for employment, especially in cases where an open roof is a feature of importance in the scheme of design.

160. Economy of construction of roofs. The question of comparative economy between steel and wood for the construction of roof trusses depends very much upon the conditions to be served. Timber trusses of all kinds are still used up to 40 ft. span, but the use of steel is increasing for all industrial buildings and is almost

exclusively used for spans over 40 ft. Timber will always be in demand however for ornamental roofs such as are used in ecclesiastical buildings and the like.

In many cases it has been found expedient and economical to compound the two materials, using steel for tension members and timber for those in compression; roof trusses of this kind are called "composite" trusses. The demand for composite trusses is now small and no doubt steel trusses will almost entirely replace them.

161. Principles of design. The design of a steel roof truss is based upon the same general principles as previously applied to wooden roof trusses, viz. the members are generally so disposed as to give direct support to the rafters at purlin points, while the bracing is treated with the view of keeping compression members as short as the selected type of truss will allow. The centre line principle can usually be adopted at the intersection of members and perfect triangulation is easy to arrange.

There is no practical gain in forming joints at right angles, hence the rectangular outline so common in the centre of queen-post trusses is not adopted. Rectangular framing causes a deficiency in roof frames; see Chapter on Carpentry. Variations from the ordinary forms of steel truss are practicable and not uncommon, these variations arising from the need to provide rooms within the roof space or other special requirements.

162. Common types of steel truss. In past days it was quite usual to arrange roof trusses in steel on the same lines as the wooden king-post truss. If the span exceeded 30 ft., additional support to the principal rafter was given by inserting extra vertical members which acted as ties, and additional inclined members which acted as struts.

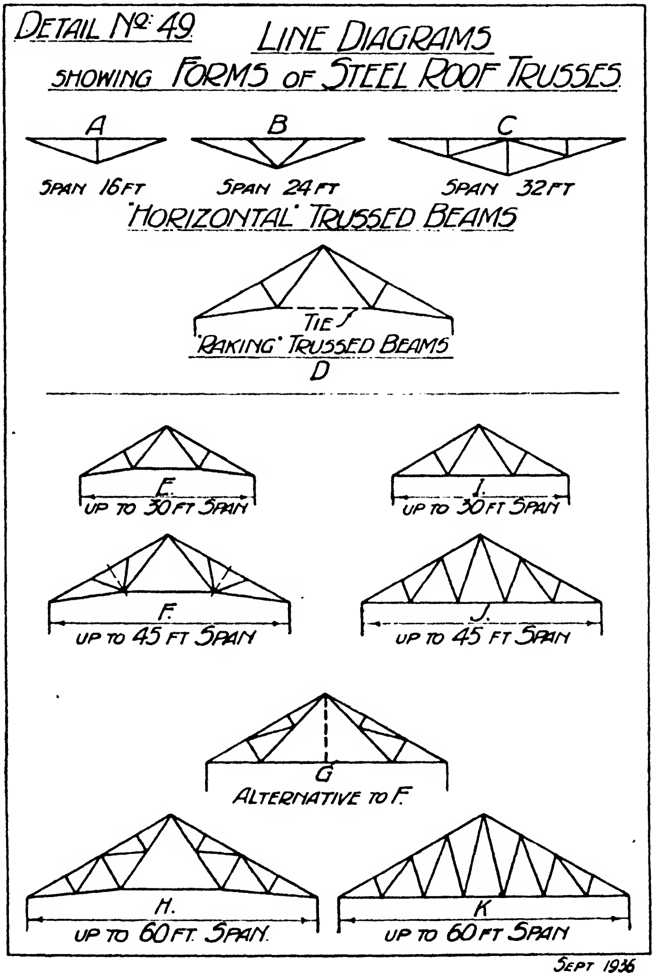
It was also usual to employ either round or flat bars for all ties and to use tee sections for all rafters and struts.

This type or class of truss was known as the queen-rod type, and is now seldom used. Since economy of fabrication is important framed construction in steel has been developed along lines which admit of easy jointing and assembly and most trusses are now made entirely of steel angles and jointed by the insertion of single gusset plates which admit of simple lapped and riveted connections.

The older forms of truss aimed at perfect symmetry in the sectional arrangement of the members, so that every member was subject to a truly axial pull. It is found, however, that, in small trusses at least, this extreme care is unnecessary, since the smaller members are usually stronger than required in order to make good practical joints. Hence single angles are often used for ties and struts, riveted to one face of the gusset plates. These, while not

axial with the centre line thickness of the truss, are found efficient and satisfactory.

The most popular forms of truss for practical use are: (*a*) the trussed-rafter roof truss and (*b*) the uniformly braced truss.



Detail No. 49 shows these two forms for various spans, placed side by side for comparison.

163. Trussed-rafter type of roof truss. The principle applied in the trussed-rafter type of roof truss is that commonly used for trussed beams.

To strengthen any horizontal beam, a strut may be placed beneath it—preferably at right angles—and the foot of the strut supported by inclined ties. Any load placed above the strut, or transmitted to it by the shortened segments of the beam, is transferred to the foot of the strut and resisted by pulls on the inclined ties. The detail No. 49 shows at A a simple trussed beam with one supporting strut. If further points of support are required—to shorten the segments of the beam, or to suit a longer span—these may be inserted as shown at B and C.

The same principle can be applied to raking beams. If two such trussed beams be raised to the slope of the roof, and be connected at the head and tied across at the feet of the struts—as shown dotted at D, an efficient form of truss is obtained.

The addition of horizontal shoes to form bearings on the supporting walls—or stanchions, as the case may be—completes the frame. (This form of truss is often known as a Belgian truss and is shown completed in outline at E.)

The essential feature of this type of truss is, that by lifting the tie and consequently shortening the struts, a more effective form than the queen-rod is obtained for construction in steel. In the illustration, the struts are 90° to the rafter and thus possess a maximum of efficiency, while, being shorter than the struts of the other type for a similar span, they have less tendency to buckle and may be of lighter section.

For larger spans the number of struts has to be increased and their positions may require them to be inclined for convenient construction.

Examples suitable for spans of 30 to 40 ft. and 45 to 60 ft. are shown at F and G and at H. G is alternative to F, the latter having struts inclined to the rafter, and the former having struts at right angles to the rafter. In obtaining greater efficiency of the struts by the right-angled arrangement and by shortening them, note that the length of unsupported tie at the centre has been increased. If, for any reason, this segment of the tie needs further support, a vertical suspension member may be inserted as shown by the dotted line in the figure at G.

164. Uniformly braced type of roof truss. This form of truss is illustrated for various spans in detail No. 49 at I, J and K.

In these illustrations the ties are all horizontal, but there is no reason why the central portions of the tie (across either one or three bays) should not be raised if desired, though the method of setting out the trusses is easier to understand by keeping the ties horizontal in the first consideration.

Uniform bracing is obtained in the following manner:

In every case the equal divisions are first made along the rafter, so that the wooden rafters may receive support from purlins—

always placed over the heads of the struts, or as near these as possible—and at distances not exceeding 8 ft. The main tie is then divided into equal spaces, one less in number than the sum of the divisions on the two rafters. The positions of the struts are then determined by joining the points on the rafter to points on the tie in succession, and working from the two ends. Diagonal ties are then inserted to complete the triangulation. Note that *struts* are inclined from the rafters inwards and downwards, and ties are inclined from the rafters outwards. The completed form of truss in every case gives support at equal intervals along the rafter and along the horizontal tie.

It should be noted that for the larger spans with this type of truss the tie should be raised at the centre if possible, both for appearance and efficiency.

The illustrations in detail No. 49 show forms of truss suitable for spans up to 30 ft., from 30 ft. to 45 ft. and from 45 ft. to 60 ft. These forms cannot, however, be taken to be definitely suitable under all conditions. The length of unsupported rafter is the main consideration in determining the exact suitability of each truss for a given span.

When the pitch is 30°, or flatter, the spans given will produce the desired result, but if the pitch be higher than 30° and the rafters proportionately longer for a given span, it may be found that some modification is desirable, *e.g.* the form normally suited to a span up to 45 ft. may have to be used for, say, a 30 ft. span—or less.

165. Methods of covering roofs—spacing of purlins and selection of form of truss. The method of covering a roof will decide the framework necessary for its support.

From previous study it is known that the usual method for supporting a slate or tile covering is to provide horizontal purlins resting on trusses, inclined rafters at 14″ to 15″ centres and running the full length of the slope, and to cover these with open laths or close boards to give immediate support to the covering. In such cases 8 ft. is the *maximum* spacing of the purlins if 4″ × 2″ rafters are used, and 6 ft. if 3″ × 2″ rafters are employed.

For the support of coverings in large sheets such as corrugated iron, Trafford asbestos tiles, ruberoid and other flexible materials a different basis may be adopted, and for factory buildings it is quite usual to modify the ordinary practice even for slate and tile coverings.

For corrugated iron and Trafford tiles, light purlins are arranged to support the length of the covering unit at the ends only, the joint or overlap between the units being made immediately above a purlin.

For ruberoid and light slates or asbestos tiles, inclined rafters may be dispensed with, and a boarded surface supported on purlins closely spaced, with the boards running in the direction of the slope of the roof.

This method will not serve for heavy coverings.

The points discussed are only of importance at the moment for deciding the positions of the necessary steel and timber framing and supports for the covering.

It has already been stated that for ordinary purlin and rafter roofs, the struts of the roof truss should give direct support to the principal rafter at purlin points; but where closely spaced purlins are used for any reason, these must necessarily occur *between* points of support to the principal rafter. The loads from these purlins therefore tend to produce *bending* of the supporting rafter—a condition which does not occur in the ordinary forms of roof construction—and hence the rafter may need to be stronger than usual.

In any case, the practice is to employ double angle rafters in steel trusses and the required strength can easily be met by designing the strength of the rafter—and other parts of the truss—to meet the particular conditions of construction and loading.

The selection of the form of truss then depends upon two things:

(*a*) To provide the number of supports necessary for individual purlins where bending of the rafter is to be avoided.

(*b*) To provide the maximum span desired in the unsupported length of a rafter, where purlins are to be placed at positions between the points of support to the rafter.

For a consideration of stress conditions on which the decisions are to be based, see Vol. III.

For the present, the student should concentrate on the methods of appropriate practical construction in steel which are available for some of the group of trusses illustrated in detail No. 49, to note the provisions made for support of different coverings and to leave to later study the question of stresses in roof trusses.

166. Form of truss for a given span. Draw the triangular outline of the truss to a small scale; decide the size of common rafter to be employed and the desirable spacing for it; measure the length of the rafter and find the number of purlins to be employed in order to keep within the prescribed spacing dimension.

Then, whatever the *form* of the roof truss selected, provide struts to support the principal rafters at, or near to, the purlin points. Refer to detail No. 49 and select a form of truss giving the required number of points of support. If the roof is an open one, viz. without ceiling, the trussed-rafter type with a raised tie is usually to be desired, especially for spans up to 45 ft.

For trusses up to this span—unceiled—use double angle rafters and single angle ties and struts jointed on to single gusset plates. The illustrative details show methods of assembling and connecting the various parts of the trusses, and the sizes of members may be taken as typical of the lighter trusses. The dimensions of the members must necessarily be varied, according to the loads to be carried and the principles adopted in designing the truss.

Raised ties are usually arranged to give a lift above the horizontal line varying from $\frac{1}{30}$ to $\frac{1}{20}$ of the span, though there is no fixed ratio.

In any case the unsupported length of a main tie should not exceed 10 ft. and where ceilings are used this unsupported length should be much reduced.

The uniformly braced type of truss is particularly suitable for carrying ceilings because of the closer and uniform spacing of the tie supports.

The level tie and double angle section are peculiarly suited to such a case.

167. Loading shed roof trusses. Consider the roof to the loading shed of the warehouse. The clear span is 29′ 7½″, so that the effective span—centre to centre of the bearings—is a little more than 30 ft. The pitch is taken as 30° for easy drawing. Quite commonly the practical pitch would be 1 unit rise in 2 units horizontal; for a common roof of uniform double slope this is usually referred to as ¼ pitch; the rise at the centre is ¼ of the span.

For a light covering, such as corrugated iron or Trafford tiles, the roof trusses shown at E and I would be suitable. These just reach their limit of 30 ft. If there were any conditions causing heavy loading—such as thick tiled coverings—it might be wise to adopt one of the forms shown at F and J in the same detail. Again, if the span were only a little more than 30 ft. it would be wise to adopt one of these forms.

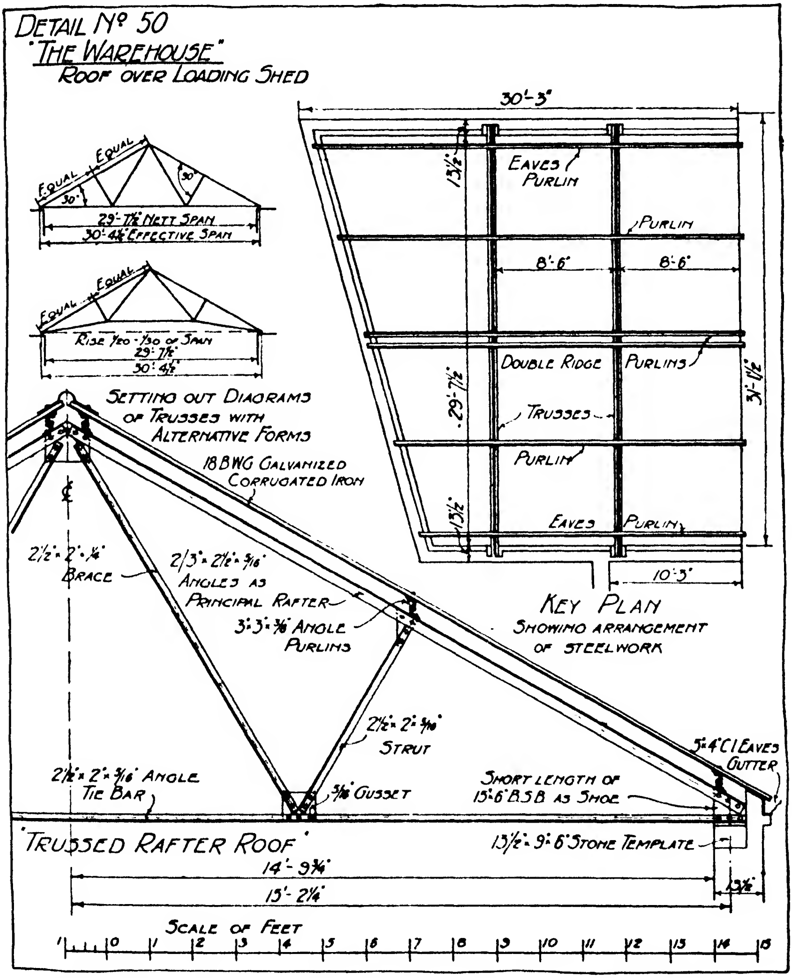
The loading shed is not to be ceiled, hence the tie may be either level or raised.

The key plan of the area to be covered, and showing the roof framing, is given in detail No. 50. Corrugated iron covering is adopted, and as this can be obtained in long lengths it is only necessary to make one lap joint on each side of the roof.

Two roof trusses are required, at 8′ 6″ spacing from the main wall of the warehouse, leaving one bay at the splayed end with an average spacing of about 9 ft. The form of the truss adopted is given in the same detail. The purlins are of angle section fixed to short angle cleats riveted to the back of the truss.

At the head of the truss a purlin is fixed on each side slope, close to the apex, which allows for the independent support of each length

of corrugated iron. The space between the ends is bridged by a galvanised iron ridge capping. The sheets are overlapped a minimum of 6″ at the intermediate joint in the length, and at the foot rain water is discharged into a cast-iron gutter.



168. **Apex joint of loading shed roof truss.** The double angle rafter—sometimes called a compound rafter—consists of two $3'' \times 2\frac{1}{2}'' \times \frac{5}{16}''$ B.S.U.A.'s (British Standard Unequal Angles). These are spaced at $\frac{5}{16}''$ apart to take the gusset plates for jointing the ends of the other members. These gussets also act as packing pieces,

though in some cases intermediate packing washers are introduced at positions between the main joints (especially in the longer lengths) in order to avoid buckling or opening of the two sections of the rafter.

The apex ends of the rafter may be either cut to a mitre (see detail No. 51 at A) or left with square ends. They are assembled on each side of the gusset and riveted, in this case with three $\frac{5}{8}''$ rivets on each side of the joint. The two inclined braces, which are connected to the same gusset plate, are single standard angles $2\frac{1}{2}'' \times 2'' \times \frac{1}{4}''$, are riveted on one face of the gusset with two $\frac{5}{8}''$ rivets to each joint. The shape of the gusset plate is decided by setting out the members so that the centre lines of the webs meet at a single point at the head of the truss, and placing the rivet centres so that outside margins are at least $1\frac{1}{2}$ times the diameter of the rivet used, and the spacing centre to centre of the rivets at least 3 times the diameter. In practice wider spacing and margins are generally used, the dimensions of these being easy measurements greater than the minimum. Thus, for $\frac{5}{8}''$ rivets, $1''$ margins and $2''$ centres are common, and for $\frac{3}{4}''$ rivets from $1\frac{1}{8}''$ to $1\frac{1}{2}''$ margins and $2\frac{1}{4}''$ to $3''$ centres. In every case the economy of gusset plate sizes should be considered, but it must also be noted that the wider spacing (and therefore longer joint) produces greater rigidity of the connection.

The detail shows the setting out of the gusset plate for the group of rivet holes.

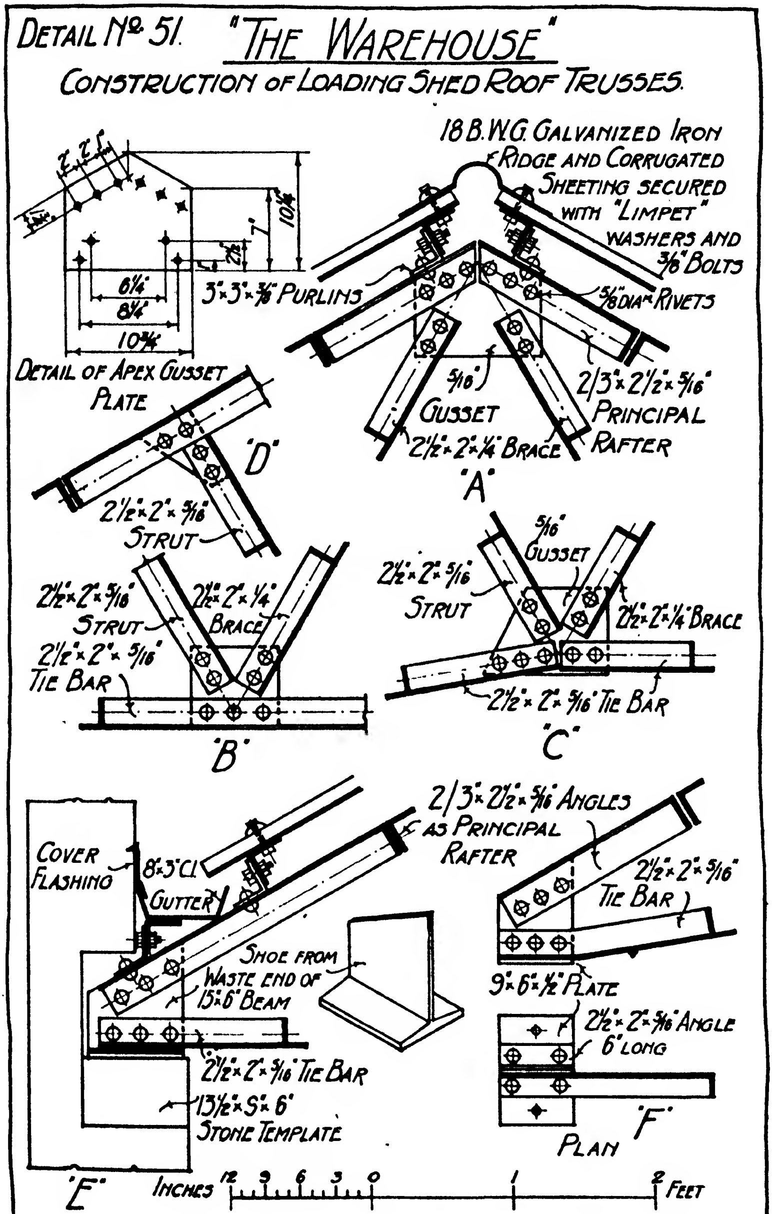
169. Joint between strut, tie and inner brace. This is shown in detail No. 51 at B. The tie is straight and continuous, and the two inclined members are arranged to lap over a single $\frac{5}{16}''$ gusset plate riveted to the tie. The setting out is again on the centre line principle, and two rivets are used for the joint at the end of each inclined member.

If the tie is raised at the centre bay, the end portions are inclined and a break occurs in the member. The two ends of the tie are therefore riveted to the gusset independently as shown at C.

170. Joint at head of strut. This is a simple joint and is shown at D in detail No. 51. A $\frac{5}{16}''$ gusset passes between the rafter sections and is riveted thereto by two $\frac{5}{8}''$ rivets. The strut is laid on the face of the gusset and fixed with two similar rivets.

The shape of the gusset should be noted. Its form is adopted so that a number of such plates can be cut from a plate $6\frac{3}{4}''$ in. wide, without waste.

171. Joint and bearing at foot of principal rafter. This joint is most important, because in addition to forming a connection between


DETAIL No. 51. "THE WAREHOUSE"
CONSTRUCTION OF LOADING SHED ROOF TRUSSES.
18 B.W.G. GALVANIZED IRON RIDGE AND CORRUGATED SHEETING SECURED WITH "LIMPET" WASHERS AND 3/8" BOLTS
3"×3"×3/8" PURLINS
5/8" DIA. RIVETS
DETAIL OF APEX GUSSET PLATE
6¼"
8¼"
10¾"
10¼"
7"
5/16" GUSSET
2/3"×2½"×5/16" PRINCIPAL RAFTER
2½"×2"×¼" BRACE
"A"
"D"
2½"×2"×5/16" STRUT
2½"×2"×5/16" STRUT
2½"×2"×¼" BRACE
2½"×2"×5/16" TIE BAR
"B"
5/16" GUSSET
2½"×2"×5/16" STRUT
2½"×2"×¼" BRACE
2½"×2"×5/16" TIE BAR
"C"
2/3"×2½"×5/16" ANGLES AS PRINCIPAL RAFTER
COVER FLASHING
8"×3" C.I. GUTTER
SHOE FROM WASTE END OF 15"×6" BEAM
2½"×2"×5/16" TIE BAR
13½"×9"×6" STONE TEMPLATE
2½"×2"×5/16" TIE BAR
9"×6"×½" PLATE
2½"×2"×5/16" ANGLE 6" LONG
PLAN
"F"
"E"
INCHES 12 9 6 3 0 1 2 FEET

the rafter and tie, provision is necessary for transmitting the load through a level base to the supports.

The most modern way of securing a satisfactory base (or shoe) and the connection, is to employ a tee-shaped piece as shown in the sketch of detail No. 51 at E. This unit is cut from a short length of 15″ × 6″ I beam, one flange being removed by a splayed cut; the remaining flange is used to act as a base on which to support the truss.

The angle tie is riveted on one side, and the double rafter forks over the top splayed end and is also riveted.

If the "shoe" thus formed is insufficient in breadth to give an adequate bearing, it can be lengthened by riveting an additional ½″ plate of the required size to the base.

The detail at F shows an alternative construction for the shoe, and also shows how an inclined tie is cranked and riveted to the shoe.

The shoe is formed from a base plate and a vertical web or gusset plate. To connect gusset and tie, the tie is continued across the face and a short piece of angle of the same size fixed on the back of the gusset. Three rivets connect the tie and the short angle and both the latter are riveted through the base plate. If it is desired to secure the shoe to the stone template built into the wall, this can be done by drilling the base plate as shown and inserting rag bolts.

The rafter is secured exactly as shown in the previous detail at E.

172. Steel purlins to loading shed roof. Opportunity has been taken in detail No. 51 to show the use of steel purlins for supporting the corrugated iron roof covering. These consists of 3″ × 3″ × ⅜″ angles and are placed with a flat face upwards. Short cleats of similar material are riveted across the backs of the rafters and the webs of the cleat and purlin are riveted or bolted through the webs which are in contact.

Detail No. 51 at A, D and E shows how the ends of the corrugated sheets are laid on the purlin backs and secured by ⅜″ galvanised bolts and limpet washers. See also paragraph 174.

173. Construction of larger span roof trusses. If a reference be made to detail No. 49 and a comparison be made between the trusses for short and long spans, it will be seen that no new principle needs to be introduced into the arrangement and construction of the larger trusses if used for the usual purpose and for normal roof loads.

As the span (and load) increases, the members must be increased in size, and possibly doubled—particularly the tie. There is no difficulty about this, nor about the jointing which only requires

perhaps thicker and larger gusset plates and to provide for a greater number of members to be assembled at one joint.

The largest steel truss which could be required in the buildings under consideration might be used as an alternative to the main roof of the warehouse, which has been detailed as a wooden truss. The span of the roof is about 42 ft., hence the form of roof shown at F in detail No. 49 would be appropriate, because the roof is not intended to be ceiled.

The reader should set out this steel truss to suit the conditions shown on the working drawings for the warehouse, detail the construction of the joints, prepare a complete working drawing of a little more than half the truss and add the support framing, covering and finishings. This roof should be covered with slates.

As a further exercise a skylight might be added in one or more of the bays of the roof on the side slope, closely adjoining the staircase wall.

174. Corrugated iron and Trafford tile covering to roof. Galvanised corrugated iron sheets are often used for semi-temporary structures. The sheets are obtainable in various thicknesses, lengths and size of corrugation. The thickness is described by the gauge or standard reference for wire.[1]

For this example, gauge No. 18 is employed, one 8′ 6″ length and one 9 ft. length being required as shown in detail No. 50 with an overlap of about 9″ at the joint to avoid cutting the sheets, instead of the minimum of 6″.

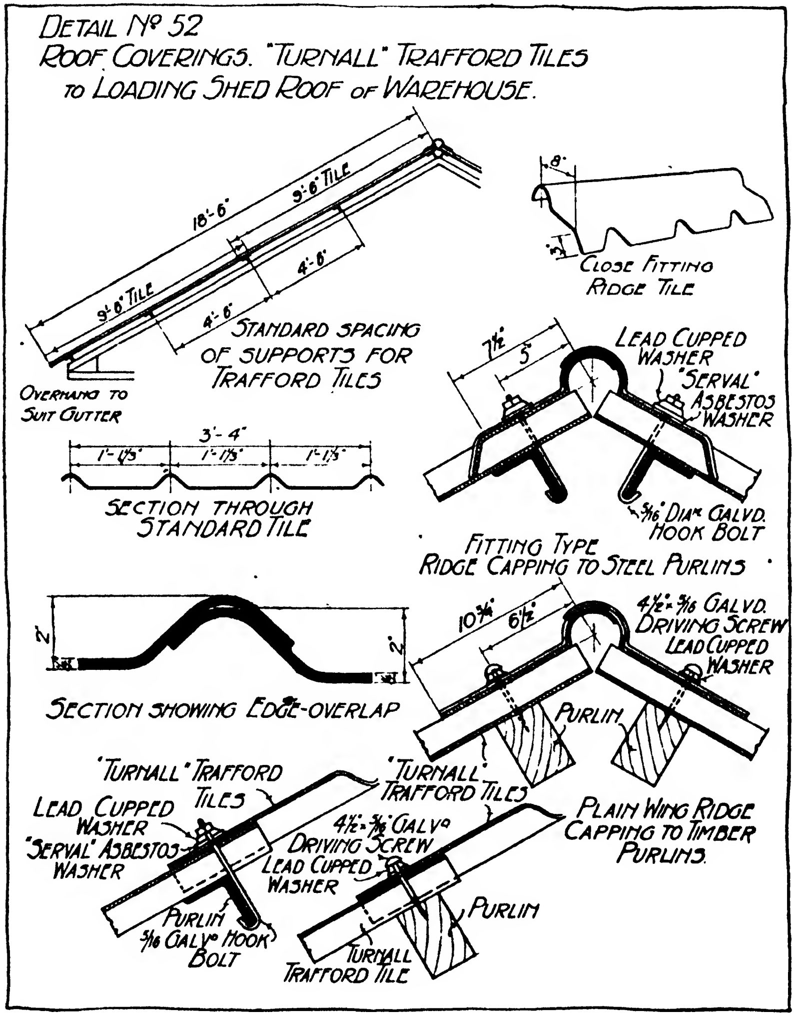
Generally, the sheets are supported at the ends and also at the overlaps and are secured by small bolts. In this example the support is provided by $3'' \times 3'' \times \frac{3}{8}'' \times 7{\cdot}18$ lbs. B.S.E.A. continuous purlins and ridge, with the flange uppermost, as in detail No. 51; the bolts securing the sheets are passed through the crown of a corrugation and the flange and the heads, outside, bear upon "limpet" washers of conical shape, which grip firmly under the pressure of the nut. The fixing may be done with ordinary bolts and round washers, but this is often unsatisfactory because the washer does not adequately guard the bolt hole and oxidation of the metal commences from leakages through the joint and rapidly develops. Rubber and composition washers are sometimes used as a safeguard against leakage and are effective for a time but soon perish through exposure to the weather. In many cases hook bolts are employed with the nut outside, the hook clasping the lower edge of the purlin web.

Where timber purlins are adopted galvanised screws are used instead of bolts, with one of the forms of washer above described.

All the fittings and fixings used for this work should be heavily galvanised.

[1] See Chapter on Materials.

To form seatings for the purlins and ridge angles, short pieces of 4" × 3" × 3/8" × 8·45 lbs. B.S.U.A., 5" long, are riveted to the rafter back. These receive the inverted angle purlins which are bolted through their webs.



Trafford tiles, in asbestos cement, form a much better and more permanent roof covering than corrugated iron—whatever steps have been taken to preserve the metal.

The Trafford tile is moulded with widely spaced corrugations

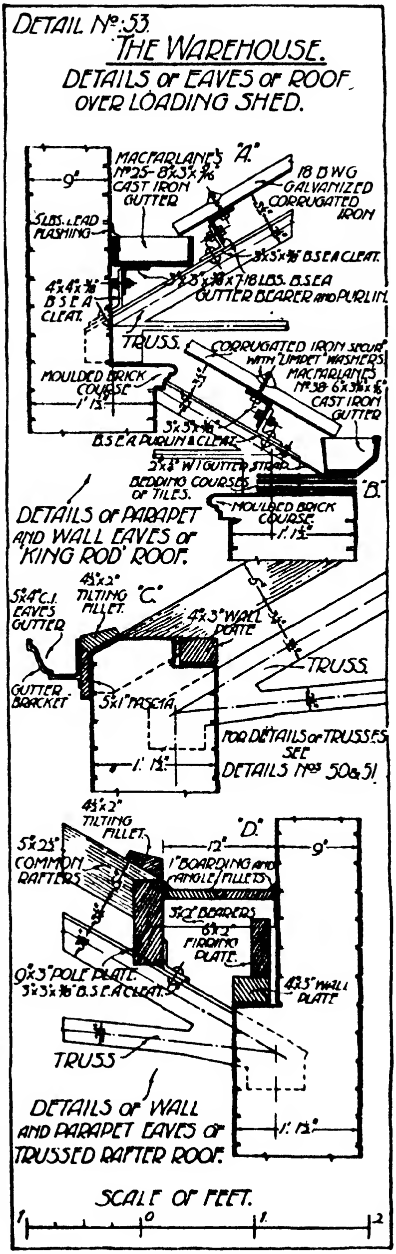
2" deep, these latter giving strength and stiffness to the sheets. The edges overlap by one full corrugation.

The tiles are ¼" thick and are obtainable in standard lengths from 4 ft. to 10 ft., the increases being in 6" intervals. The overall standard width is 3′ 8" and the net covering capacity 3′ 4".

Detail No. 52 shows the form of the tile, the method of overlapping and fixing, finish at eaves and ridge, and the purlin spacing. The latter must not exceed 4′ 6".

The method of laying and fixing largely corresponds with that of corrugated iron, but asbestos weather-proof washers and ferrules are used with the galvanised metal hooked bolts and wood screws.

Special forms of finishing pieces are obtainable for skylights, ventilators, dormers etc. and also turn-up pieces against walls.



175. Ridge finish to corrugated covering. At the ridge of the truss the angles are brought as close as convenient and the space between the ends of the sheets bridged by a special corrugated ridge cap, as in detail No. 51, bolted at the overlaps and also at occasional points along the ridge by bolts bearing upon bent wrought iron washer plates which clasp the heads of the corrugated sheets.

Ornamental and ventilating ridge caps may be obtained for use with the standard forms of corrugated sheets.

176. Eaves support and finish to corrugated covering. In the loading shed roof there are two types of eaves finish. One occurs behind a parapet overlooking the back street, and the other at an open eaves overlooking the yard.

Detail No. 53 shows these terminations, with the supports for the corrugated sheets. At A, is shown an $8'' \times 3'' \times \frac{5}{16}''$ cast iron gutter, resting at the back edge upon a $3'' \times 3'' \times \frac{3}{8}'' \times 7{\cdot}18$ lbs. continuous angle support, connected to the rafter by a $4'' \times 4'' \times \frac{3}{8}''$ splayed steel cleat, 5″ long, riveted to the back of the rafter; at the opposite edge the gutter bears upon the rafter.

The joint between wall and gutter is covered by a lead apron flashing of 5 lbs. lead, about 4″ wide.

At B, is shown a plain eaves gutter $6'' \times 3\frac{3}{4}'' \times \frac{5}{16}''$ thick, projecting 2″ over the wall and bedded upon tile courses for adjustment of the falls, as described in Vol. I.

The down pipes for this gutter could, if necessary, be carried in chases formed in the brick wall, but open to view on the external face.

177. Preparation of steel roof for ordinary roof coverings. Where an ordinary covering is to be employed, wooden purlins and common rafters may be provided as in earlier examples or, as an alternative, steel purlins of **I** or L section may be used, to which the common rafters would be fixed by bolting wooden plates or fillers to the steel; the rafters would then be nailed to the fillers. Steel **I** purlins are excellent for bridging long spans.

178. Ridge and eaves preparation. At the ridge, pairs of splayed steel cleats $4'' \times 4'' \times \frac{3}{8}'' \times 3\frac{1}{2}''$ long are riveted to the rafter back to form a seating for a $10'' \times 2''$ deal ridge.

For the feet of the slopes two methods are given in detail No. 53, a parapet gutter at D and an ordinary eaves gutter at C. The parapet gutter is of parallel plan, 12″ wide, formed by the wall on one side and on the other by a $9'' \times 3''$ pole plate notched over the rafter and bolted to a $3'' \times 3'' \times \frac{3}{8}''$ splayed steel cleat $3\frac{1}{2}''$ long. A 1″ gutter bottom rests on $3'' \times 2''$ bearers 12″ apart, which are tenoned to the pole plate at one end, and at the opposite end rest upon a $6'' \times 2''$ firring plate placed upon a $4'' \times 3''$ wall plate for support. The fall of the gutter is adjusted by varying the depth of the firring to accommodate the slope and drips; the section given is through the highest level of the gutter.

The eaves at C is finished by a $5'' \times 4'' \times \frac{1}{4}''$ moulded cast iron gutter which is supported upon brackets screwed to a $5'' \times 1''$ fascia placed against the wall and secured by nailing to the ends of the rafters; the latter pass over the supporting wall plate and extend to the outer wall face.

CHAPTER NINE

SUBSIDIARY METAL CONSTRUCTIONS

179. The construction of the heavier steelwork in stanchions and floor beams is considered in Vol. III, but it is convenient here to consider the subsidiary metal constructions which are required to provide for the security and comfort of the occupants of a building.

Many such details are not structurally important, beyond the fact that they guard open areas, accessible windows, fanlights, etc., where such protection is essential.

A good opportunity is provided in many of these apparently minor features for effective architectural treatment, which does not always receive the attention it deserves, with the consequence that an otherwise well conceived scheme of design is often marred.

It is convenient to include in this chapter some substitutes for and alternatives to other materials, *e.g.* metal handrails, casement frames and sashes, and skylights.

Handrails to Stairs

180. Handrails to stairs are necessary to provide assistance and security to persons using them, and also as a guide to the rise and fall of the stair when there is an absence of light through faulty design. The handrail is usually supported on vertical balusters, or other ornamental filling, the whole forming an open-work guard known as a balustrade.

181. Iron balustrade and handrail to external stair of loading shed. This stair is a short external flight built against the warehouse wall and giving access to the loading shed from the front street—detail No. 28. The balustrade acts as a guard to the open end and consists of a series of vertical wrought iron balusters, 1″ square, forged to a ragged dovetail or lewis end and housed and leaded into the treads of the stair, two to each step. The lead is run into the dovetailed housing in a molten state, caulked when solid like a hinge gudgeon[1] and care taken to avoid sinkings below the level of the step in which rain may be retained. If the latter occurs, a very rapid oxidation of the wrought iron is caused, due to galvanic action.

The top ends of the balusters are secured to a 2″ × ⅝″, or larger, handrail of segmental section, by countersunk set screws, or as an

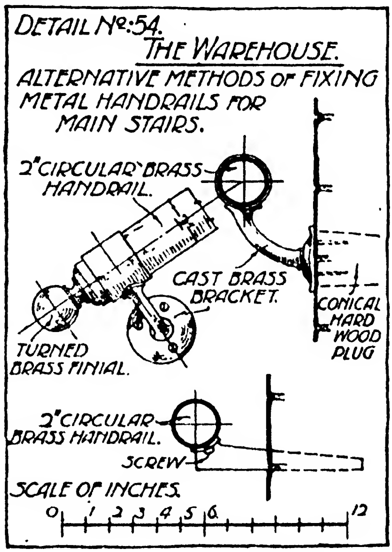
[1] See Vol. I.

alternative, the balusters may be prepared with pins screwed into their bevelled top ends and the pins riveted through countersunk holes in the rail and filed flush.

The handrail terminates at the foot with a small scroll and is secured to the wall above the landing by means of a ragged or lewis end, which is either housed, wedged and pointed with cement mortar or run with lead like the feet of the balusters.

If the stair is longer than that of the example a larger baluster, or newel, $1\frac{1}{2}''$ square should be placed at the foot, or some other alternative adopted to secure a rigid end to the handrail at the foot of the flight. Grouping of balusters will secure this as adopted in detail No. 55 and described in paragraph 187.

182. Heights of handrails. For this external stair the height of the handrail is made 2′ 9″ above the top front edges of the steps, measured vertically. The selection of this dimension depends much on personal preference varying from 2′ 7″ to 2′ 10″ on the rake of the stair and from 2′ 10″ to 3 ft. on landings. See also Vol. III.



183. Metal handrails to enclosed stairs. Handrails are necessary for most stairs even though the flights may be short and guard walls enclose them. The rails may be of wood or metal for interior work and, though a good wooden handrail is more comfortable for use, metal ones are stronger and more durable for commercial premises and are often employed.

Detail No. 29 shows the general positions of the metal handrails applied to the main stairs of the warehouse and No. 54 illustrates in greater detail the commoner methods of supporting and fixing the rails.

Some metal handrails are made continuous, being bent round the return angles so that assistance is provided without break throughout successive flights. This continuity is unnecessary in straight flights, though it may be convenient; at the same time the convenience does not often justify the expense.

184. Hollow brass handrails with solid stopped ends. The handrails selected are of cylindrical brass tube about 2″ diameter and $\frac{3}{16}$″ thick. The ends are stopped by solid turned pieces screwed into the tube.

For very economical work pieces of wrought iron tube $1\frac{1}{2}$″ diameter are sometimes employed, the ends being left open, or stopped by screwed cups on the outside. Joints in the length, where necessary, are commonly made with ordinary screwed unions which interfere with the continuity of the external surface; unions and stops of this kind should be placed internally to avoid inconvenient projections.

185. Methods of supporting metal handrails. Two methods of supporting metal handrails are shown in the detail.

In the lower sketch a flanged holdfast or carrier, with a curved seating for the handrail, is driven into a brick joint, or preferably prepared with a lewis end, housed and run with lead. The rail is then screwed to the curved seating with two set screws, one to each flange. If the position of the set screws causes them to be inaccessible for screwing the rail on to the carriers after fixing, these should be first fixed to the rail, then the housings cut, all carriers inserted together and run with lead in succession.

With thin tubes such fixings often fail at the screws.

An alternative method for fixing is to employ a sleeve which is brazed or riveted to the supporting bracket and encloses the rail as in the upper detail of No. 54. For convenience of handling the sleeve must be thin, with the sharp edges removed and for strength should be brazed or screwed to the rail. The bracket may be fixed to the wall either by a lewis end, or provided with a drilled bearing plate which is screwed to a conical hard-wood plug driven into the wall. Dry firm plugs neatly fixed and long tension screws may make a satisfactory fixing.

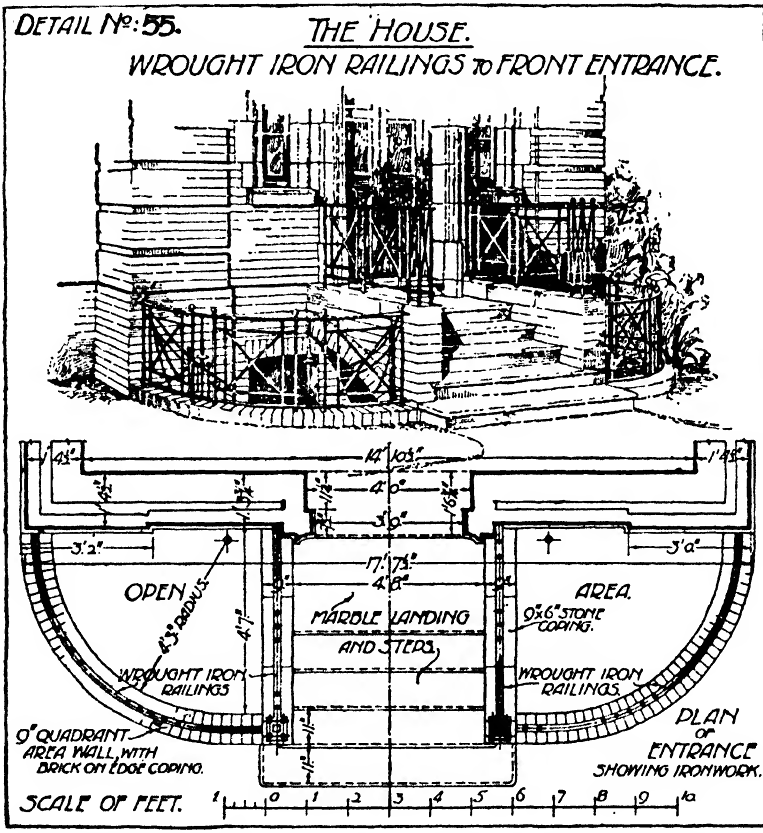
There is always, however, a measure of insecurity about such fixings because the material used for the plug may shrink or the hole may be tapered too acutely and the constant use cause loosening, hence the following method is suggested as being more satisfactory and efficient.

Holes are drilled cleanly in the wall with a special tool and fibre plugs of tubular form known as "Rawl-plugs" are tightly inserted. On the insertion of a screw of suitable size the fibre is expanded and securely held by its pressure on the sides of the hole.

Other types of plug are spiral metal plugs and folded lead, the former being particularly useful for casting into concrete and the latter for use in drilled holes in brick or stone.

Railings to Front Entrance of House

186. The front entrance to the house is approached by a flight of steps supported by a rampant arch across the open area in front of the basement. The steps are flanked by two low guard walls upon which wrought iron railings 2′ 6″ high are erected, as in detail No. 55.



Similar guard railings are also provided upon the copings of the curved wing walls to guard the area.

187. Wrought iron railings. The railings are of wrought iron, arranged in rectangular units or panels divided by one or more vertical bars to suit the spacing and accommodate the units to the general dimensions.

The side rails to the entrance have two units each, with a single bar division which is necessary for fixing, and terminate at the front in a group of four vertical bars. All these main verticals are $\frac{3}{4}''$ square and are continued to the coping, housed $1\frac{1}{2}''$ to $2''$ into it and run with lead. The purpose of the group is to provide a rigid fixing somewhat like a framed newel post, which also adds to the architectural effect. The top and bottom rails of the units are continuous flat bars, which are welded or screwed to the hollow square frames containing the newel group. The top rail would be carried to the wall and secured by a lewis end.

188. Design and construction of railings. In designing railings the exact form of the parts should be decided according to the proposed mode of jointing and the latter should be taken into account by the designer.

Round iron rods cannot be usefully included in any but straight line lengths placed between or passing through square or flat bars. Rods of square or rectangular section may be combined into almost any outline, as the junctions may be lapped and riveted, butted and screwed, tenoned and riveted or halved and pinned and in very many cases welded together by the craftsman.

Ornamental terminations are either separately forged and welded on to plain bars, or tapped and screwed together.

In the example the upper horizontal bars are intended to be of $1\frac{1}{2}'' \times \frac{1}{2}''$ metal, the main uprights $\frac{3}{4}''$ square and the subsidiary marginal bars $\frac{5}{8}''$ square. Diagonals to panels and braces to the framed newel termination may also be $\frac{5}{8}''$ square or reduced at the will of the designer. A specially turned bar divides the units or panels.

189. Rigidity of railings and mode of securing. Railings must be rigidly secured and must of themselves be stiff enough sidewise to resist considerable pressure. In long lengths they are usually made rigid by inclined stays at intervals of 6 to 12 ft. according to the strength of the rails. The stays are riveted or screwed to the top rail or to some of the stiffer vertical members, and secured to the stonework at the foot. For the latter purpose, in the case of large boundary railings, attached piers are often built to receive the stays and the copings extended over them; this enables the stays to be more widely spread at the base and adds greatly to their efficiency.

Inclined stays often interfere with the scheme of design, but with careful treatment may not be detrimental; on the other hand, a better architectural effect is obtainable by grouping rods in rectangular outlines in plan and thus by embodying such groups in the design and making proper provision for them in the coping inclined stays may be avoided. All such copings should be sufficiently weathered to allow water to drain off freely. This may be

done without emphasising the weathering, if it would interfere with the scheme of design.

190. Curved railings. When railings are curved in plan as occurs in the wing walls of the area in detail No. 55, they possess a great rigidity owing to the stiffness of the curved rails in their horizontal planes. These rails act as arches against any external thrust, hence, if sufficient end-fixing is given to the rails and an adequate number of vertical rods are continued to the coping, back stays may often be dispensed with.

The curved railings in the example are similar to the straight portions at the sides of the entrance steps and include a turned bar between each pair of panels; the type of design employed is such that it may be adapted to panels of varying size without destroying the unity of the design.

Metal Casements

191. Metal sashes and frames, commonly referred to as metal casements, are now in general use for all classes of buildings. These casements are made in iron, steel or bronze, and may be fixed into wood frames or directly to the brick, stone or concrete surrounding window openings.

Iron and steel sashes require to be well preserved by painting before fixing, and also at intervals, to prevent oxidation.

192. Types of metal sash. The commonest form of sash frame is an assemblage of light rolled steel sections of angle, tee or channel outline, or combinations of these at opening parts, where necessary to protect the joints from penetration of rain and wind.

If applied to wooden frames, the latter may be either rebated to receive them, grooved to enclose them, or they may be neatly fitted into a square edged frame.

If applied to stone or similar openings directly, they may be built in position along with the surrounding work, screwed to built in lugs after the opening is complete or bedded into shallow rebates in the same manner as wooden frames.

Some casements have special forms of moulded bar which are assembled by interlocking methods, *e.g.* Hope's "lok'd bar" and Crittall's patent casements, which are fully detailed and described in later paragraphs.

193. Opening parts. Portions of all types of sash may be made to open, the position of the opening parts being dependent upon the scheme of ventilation and the practical convenience of any proposed arrangements.

The forms of the opening portions are similar to those applied in wooden sashes and include side hung and centre hung lights, hopper lights and casements pivoted in vertical planes. Horizontal sliding sashes are also in use.

Special arrangements in the details of the frames are required for accommodating opening parts as will be seen in studying the following text and details.

194. Metal casements in wood frames. Detail No. 56 shows a steel casement fitted to a plain wood frame and applied to the side windows of the front entrance to the house. The frame is of oak, with $3'' \times 1\frac{3}{4}''$ stiles and $3'' \times 2\frac{1}{2}''$ sunk, weathered and rebated cill; the steel casement, 1″ thick over the standard parts, is set in the centre of the frame. In this example the middle portion of the casement is fitted with a hopper light the full breadth of the sash, which necessitates Z bars being used for each of the horizontal members where lap is needed for weather resistance; L and T bars are used for other members of the casement and for the opening part. The function of each member and the reason for its selection should be clear from the plan and section given.

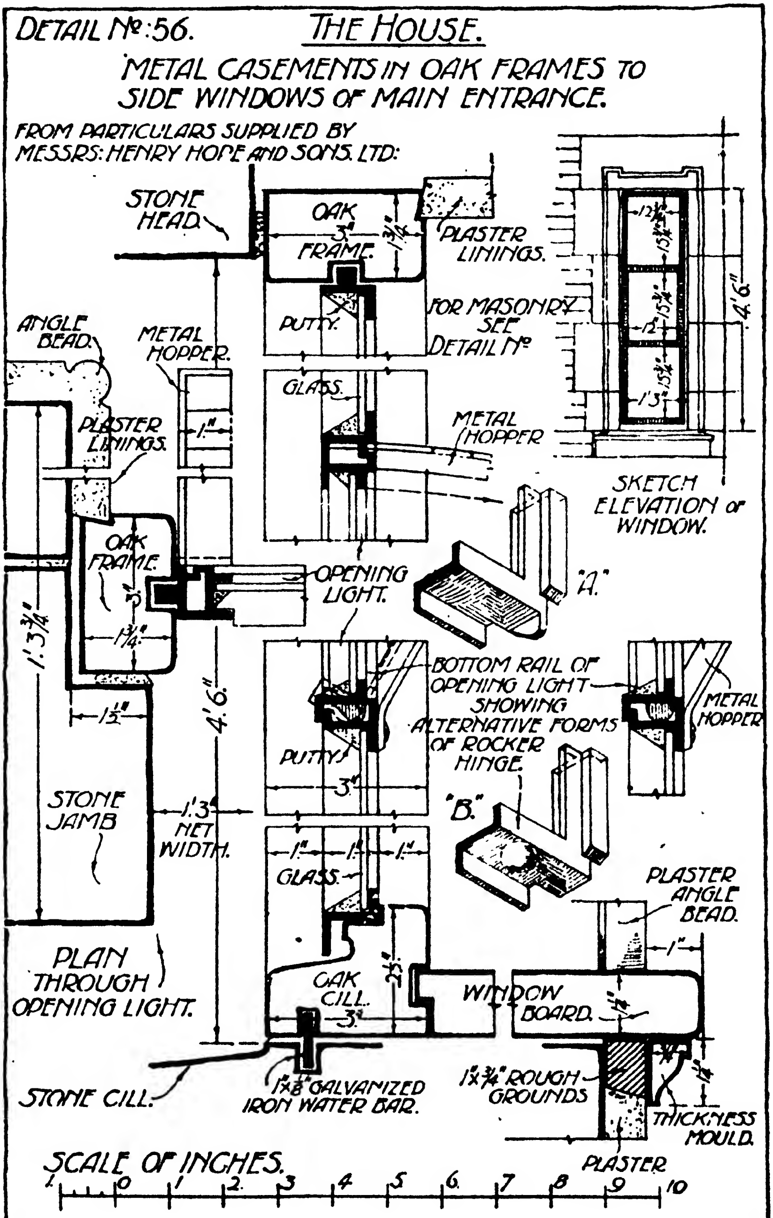
In the best work the members are butted and set screwed at the angles and also welded or brazed at the joints. If the material is too thin for screwing, brazing or welding is adopted and where the sections allow it, riveted tenons may be employed.

195. Hopper lights in casements. When the opening light or sash is required to swing hopperwise, the intermediate bars of the frame may be arranged as shown in the detail.

The opening "light" is prepared with a bottom rail which overlaps the top bar of the lower light on the outside and, in Hope's patent form, has a rocker bearing upon which the light rotates, thus preventing the common difficulty of hinging, and the trouble that arises through hinges getting out of order due to oxidation and disuse during certain periods of the year.

Two forms of rocker are shown in the detail at A and B, one being a shaped continuation of the stile of the light and the other a separately fixed spherical piece of larger size. The action of the rocker can be seen by the dotted lines in the detail and no serious interference with its rotation can take place even though the metal has been allowed to oxidise and the bearing surface to deteriorate.

Hopper cheeks of angle section are necessary to prevent the sash from falling out, and these may be glazed at the sides to confine the discharge of fresh air in an upward direction into the room. This is an advantage over the pivoted light which allows the incoming air to drop downwards and sidewise immediately on passing the opening.


DETAIL No:56.
THE HOUSE.
METAL CASEMENTS IN OAK FRAMES TO SIDE WINDOWS OF MAIN ENTRANCE.
FROM PARTICULARS SUPPLIED BY MESSRS: HENRY HOPE AND SONS LTD:
STONE HEAD.
OAK 3" FRAME.
PLASTER LININGS.
PUTTY.
FOR MASONRY SEE DETAIL No
ANGLE BEAD.
METAL HOPPER.
GLASS.
PLASTER LININGS.
METAL HOPPER
SKETCH ELEVATION OF WINDOW.
OAK FRAME.
OPENING LIGHT.
"A."
BOTTOM RAIL OF OPENING LIGHT SHOWING ALTERNATIVE FORMS OF ROCKER HINGE.
METAL HOPPER
PUTTY
"B."
STONE JAMB
1'3" NET WIDTH.
GLASS.
PLASTER ANGLE BEAD.
OAK CILL.
WINDOW BOARD.
PLAN THROUGH OPENING LIGHT.
STONE CILL.
1"x8" GALVANIZED IRON WATER BAR.
1"x¾" ROUGH GROUNDS
THICKNESS MOULD.
PLASTER
SCALE OF INCHES.
1 0 1 2 3 4 5 6 7 8 9 10
4'6"
1'3¾"

In order that the opening sash may be placed in position or removed at any time, the top bar of the hopper frame is slotted, as shown in the detail.

196. Methods of securing metal casements in wood frames. There are several methods of securing the metal sashes to their frames. The one shown in the details is to make the casement a neat fit against the stiles and head of the frame, and into the square rebate of the cill. Metal sockets are tightly fitted at convenient positions in the wood frame and the casement secured by set screws through the stiles, head and cill before glazing. To obtain a weathertight joint by this method the frame must be set out to suit the casement exactly and the best result is obtained by cramping the frame together and wedging it up with the casement inset; the whole of the casement and frame should be well painted in oil colour and the edges thickly coated with red lead and oil when about to cramp and wedge the frame; the edges are thus bedded close and a tight joint is made.

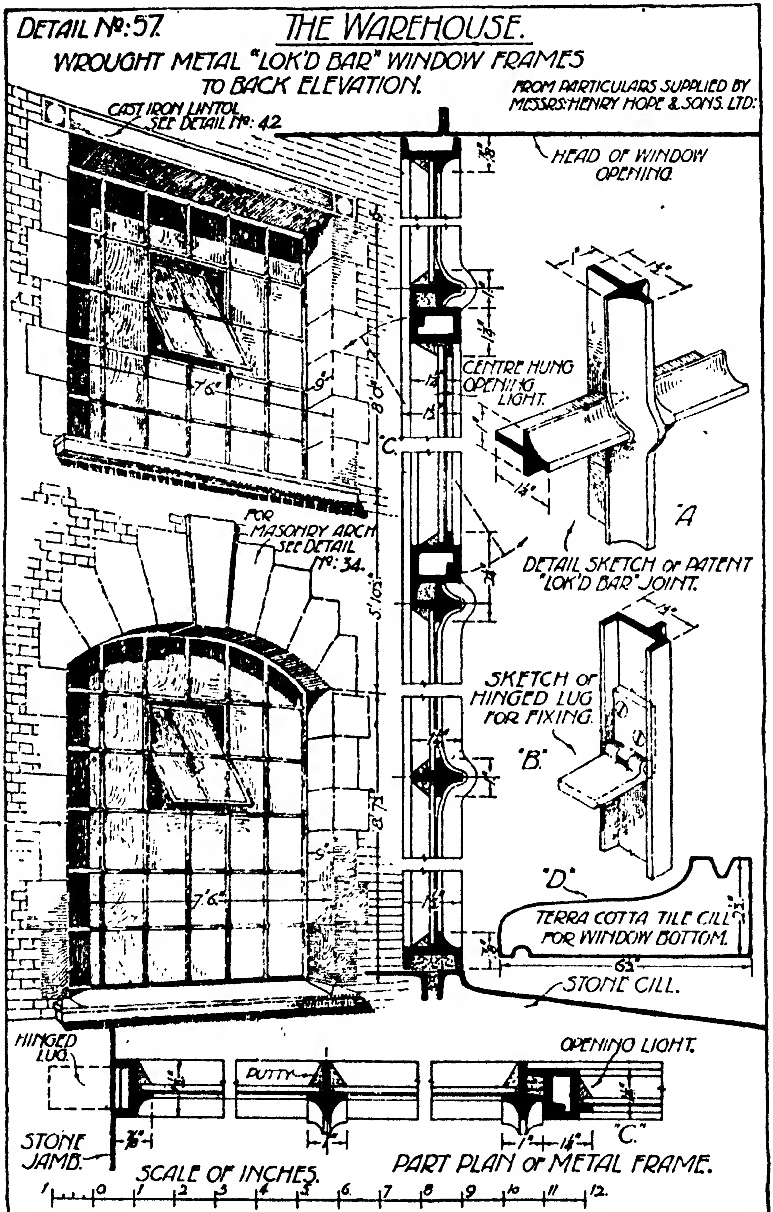
A better method is to house the sash bodily into the frame $\frac{1}{8}''$ deep, but this prevents the sash being removed for any subsequent repairs; it also interferes with the fitting of side hoppers unless the segmental rail is brought within the frame.

Probably the best and most convenient method is to place the casement in a shallow rebate, bed in oil putty and screw through the sides of the casement as before described. The rĕbate may be internal or external according to the nature of the frame and the possible interference on insertion by the opening parts or their accessories.

The method of keeping the casement weathertight at the cill is shown in section, and consists of an overlap forming a screen or weather guard to the horizontal joint. It is similar in principle to the details of wood sashes already described in Vol. I.

197. Hope's "Lok'd bar" steel casements to warehouse. Detail No. 57 illustrates large steel casements of the "lok'd bar" pattern applied to the back windows of the warehouse. The openings are 7′ 6″ wide and the casements are divided into comparatively small panes. A pivoted light in the casement includes two panes in width and height.

In the enlarged section the bars are shown to be hollow moulded and rebated, but with a difference in size and shape between the vertical and horizontal members. The vertical members are $1\frac{1}{2}'' \times 1''$ and the horizontal ones $1\frac{1}{4}'' \times 1''$ with a narrower rebate and a thinner edge to the mould where it meets the glass. The object of this difference is to allow special locked joints to be formed at the intersections of the bars; this is done by punching a hole through


DETAIL No: 57
THE WAREHOUSE.
WROUGHT METAL "LOK'D BAR" WINDOW FRAMES
TO BACK ELEVATION.
FROM PARTICULARS SUPPLIED BY
MESSRS HENRY HOPE & SONS. LTD:
CAST IRON LINTOL
SEE DETAIL No: 42
HEAD OF WINDOW
OPENING
CENTRE HUNG
OPENING
LIGHT.
FOR
MASONRY ARCH
SEE DETAIL
No: 34.
DETAIL SKETCH OF PATENT
"LOK'D BAR" JOINT.
"A"
SKETCH OF
HINGED LUG
FOR FIXING.
"B"
"D"
TERRA COTTA TILE CILL
FOR WINDOW BOTTOM.
STONE CILL.
HINGED
LUG.
PUTTY
OPENING LIGHT.
STONE
JAMB.
"C."
SCALE OF INCHES.
PART PLAN OF METAL FRAME.

the vertical bar, expanding the moulded portion to admit the horizontal member bodily, then pressing the disturbed mould against the moulded edge of the continuous and lesser bar. The result is shown in the sketch at A and produces a very good architectural effect by the relief given to the joints; it will be seen that in order to obtain this the window is glazed from the inside, although it could, if necessary, be reversed.

The stiles, head and cill of the frame correspond to the larger bars in size and shape on the intersecting edges, but are only $\frac{7}{8}''$ thick, with two back flanges as shown in section. The sash bars are joined to the frame by riveted tenons formed on the rebate portion of the bar, the moulds being mitred together. Angle joints are similarly formed.

198. Methods of fixing in position. Casements of large size are usually fixed direct to the stonework of the opening. This gives more light and suits the severe outlines adopted in many modern buildings; it reduces the *appearance* of strength and durability as compared with steel casements in wood frames but as the cost of hard wood frames is not justified they are seldom adopted.

The methods available for fixing the frames are:

(*a*) By screwing to fixing lugs which are either built into the jambs or housed and run with lead or cement on completion of the walling.

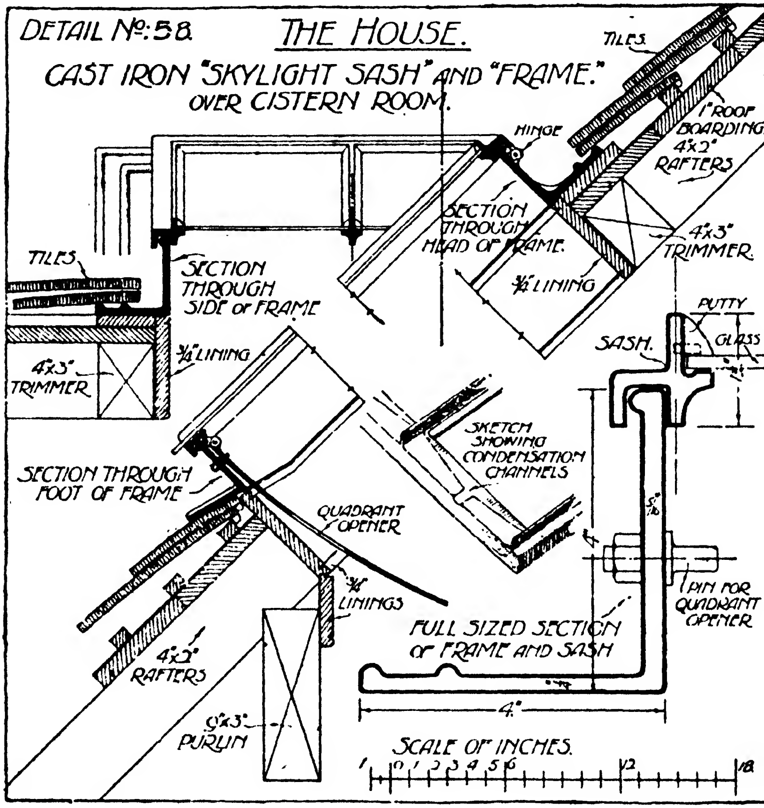
(*b*) Providing a shallow recess for the reception of the frame, bedding in oil putty and wedging in position, then enclosing the edges by plaster.

(*c*) As in (*b*) but securing the casements to the jambs by screws through the sides of the frame into either lead, Rawl, or iron lewis plugs.

(*d*) By hinged lugs attached to the frame, as shown at B in detail No. 57. These can be folded against the frame for insertion, and afterwards turned down into a chase previously cut in the reveals, and stopped with cement mortar.

199. Centre hung lights in "lok'd bar" casements. The plan and section of the detail show how pivoted lights are arranged. A special frame to receive the light is inserted as indicated at C in plan and section, the hollow space of the rebate in the sash bars being stopped solid with putty and the adjoining members screwed together. This frame has a covering rib for the rebate receiving the pivoted light, and a small rib to act as a stop; it will also be observed that the shapes of the top and bottom rails of both frames and sashes are reversed in form, to allow the upper part of the sash to work inwards and the lower part outwards. In a similar manner the section of the

stiles must change above and below the pivots to accommodate the movement and render weathertight, the method corresponding to that adopted for pivoted wood sashes—see joinery details.



Iron Skylights

Small skylights required to open for ventilation are often made of cast iron and are cheaper than wood, because lead-work can be entirely dispensed with; they are also more durable.

200. Skylight frame. The frame is a metal curb 3″ to 5″ high with a projecting flange all round its external edges. At the head the flange passes well under the slates, tiles or other roof covering, and the angle between flange and curb forms a gutter for the collection and discharge of water from the higher part of the roof

behind it. It is an advantage if a tapered fillet is cast in the angle to cause a fall in each direction from the centre.

The side flanges usually have one or two beads, over which the slates are raised, the latter being cut to butt closely against the curb. Water from the gutter travels down the side flanges and is confined within the beads and curb, which form a side gutter.

At the lower flange a tilt is commonly given to conform to the slope of the roof covering so that this portion overlaps it at the foot and renders an apron flashing unnecessary.

Detail No. 58 shows the form of a suitable frame for an opening light, with the position of tiling in both longitudinal and cross section.

201. Skylight sash. The sash may suitably be cast to the form shown in the same detail, the rim and bars being arranged for easy glazing and a turn down edge or weather guard provided all round the sash.

For hinging the light, two lugs are cast on the head of the frame and underneath the sash, and one long bolt or two short bolts are employed as hinge pins.

If painted in oil at the glazing rims there is no difficulty in getting putty to adhere and thus obtain watertight glazing. The whole should be well preserved by paint before fixing.

Patent Glazing on Steel Roofs

202. Principle of patent glazing. The term "patent glazing" is now commonly applied to all methods of fixing glass in roof lights, etc., without the employment of putty, the object being to allow of speedy and economical replacement of broken panes of glass.

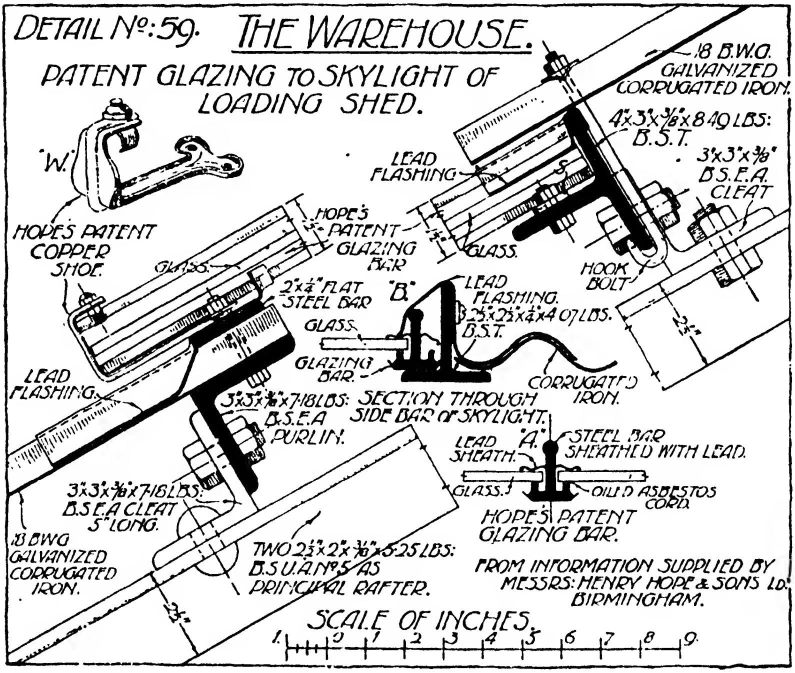
There are many systems in use, most of which embody some variable method of enclosing the edges of the glass between folds of lead, the latter being mounted on wood bars, or deposited as a covering to steel bars of special shape. Reinforced artificial stone bars are also employed to support glazing.

Bedding of glass. In most instances the glazing is bedded upon cords of asbestos or oiled string and kept in place by a wing of lead folded down upon it as in the section of detail No. 59 at A. In this case the fold is stiffened by its beaded edge and corrugated section, though in some cases the wings are quite plain.

Leakages and condensed moisture. To provide against leakages which may possibly occur through the wings being lifted in a gale "leakage channels" are formed in the bar, and in the best examples, possible side trickling of condensed moisture on the under side of the glass is provided for by a further channel. To clear the main flow of condensed moisture, there must be an open course, through the connection and support, at the foot of the light.

203. Hope's method of patent glazing. This system may be applied to skylights in any form of roof construction and to any kind of covering.

The illustration in detail No. 59 shows the application to a skylight which is an alternative to the wooden skylight dealt with in paragraph 401, and is shown in conjunction with corrugated iron roofing on steel trusses as previously described, and detailed at Nos. 50 and 51 in the chapter on steel roofs.



204. Preparation for support of glazing bars. To support the glazing bars, steel members are bolted to steel angle purlins of the usual type. At the foot, the light rests upon the ordinary steel purlin, while at the head a $4'' \times 3'' \times \frac{3}{8}''$ steel tee is fixed with its web parallel to the plane of the roof. It will be observed that the skylight is not quite parallel to the roof plane but is a little flatter, so that the head of the glazing passes under the covering, while the foot stands above it.

To support the glazing bars at the foot a $2'' \times \frac{1}{4}''$ flat bar is placed upon the corrugated sheeting above the purlin covered by a lead flashing and receives upon its top face copper shoes or stops, bolted to the purlin. These in turn receive the feet of the glazing bars at

18″ to 24″ centres and also retain the glazing and prevent slipping, by the projecting wings at W.

At the head the bars rest upon flat seatings, S, to which they are screwed, and the latter rest upon and are bolted to the web of the supporting tee.

205. Section of glazing bars. The section of Hope's glazing bar is shown at A; it is a steel tee about $1\frac{1}{2}'' \times 1\frac{1}{4}''$ and $\frac{1}{4}''$ thick, having a bulb top edge or flange, two leakage channels, raised and grooved seatings for the glass and a complete covering of lead. The lead has two curved wings to the web which fold over and retain the glass and also two side channels at the edges of the bottom flange for gathering the side flow of condensed moisture. An excellent protection to the steel is given by the lead clothing.

These bars may be obtained of different sizes in order to accommodate designs for different spans, but the size in most common use is the one given above, which may be employed for clear spans up to 8 ft.

206. Side support and finishing. To terminate the sides of the light where they intersect the roofing, $2\frac{1}{2}'' \times 2\frac{1}{2}'' \times \frac{1}{4}''$ steel tees are run parallel to the glazing bars from the head to the foot bar, resting upon these and bolted together.

The position of the tee is decided by the required position of the last glazing bar which rests upon the bottom flange, as shown at B. One side of the glazing bar is in active use, the other, in this case, being bridged over by the lead side flashing. Other examples of patent glazing bars are shown in Vol. III.

Lead Flashings to Patent Glazing

207. Hope's patent glazing—method of flashing. By this method of arranging a glazing light in a sloping roof covered with corrugated iron, flashings of lead are employed on all edges where the light intersects the covering, as shown in detail No. 59.

The head flashing is a piece of 5 lbs. lead, 4″ broad, and is turned over the edge of the steel tee upon which the corrugated iron covering is supported, and dressed down upon the glazing and over its lead-covered bars.

At the sides the flashing, 6″ wide, lies over one complete corrugation of the covering, turns up the side of the steel tee forming the margin and folds on the inside over the top edge of the marginal glazing bar. These side flashings are secured by short set screws and flexible or lead washers as shown in the cross section.

The flashing at the foot of the light is about $7\frac{1}{2}''$ wide, dressed over the corrugated sheeting, then turned up to enclose the flat

metal bar on which the glazing bars are afterwards seated and by a second upturn brought into loose contact with the glass.

208. Method of laying lead flashing. The flashings are placed in position as soon as the corrugated covering has been laid below the light and along each side of it.

The order of laying is: (1) base flashing, (2) side flashings, continued to overlap the base flashing at each angle, and (3) head flashing which overlaps the side flashings. The principle of laying is the same as for a wooden skylight.

On completion of the flashings the upper lengths of corrugated sheeting can be bolted down where they overlap the light. These are easily removable for subsequent repairs to leadwork.

CHAPTER TEN

STRESSES IN FRAMED STRUCTURES

Introductory note

This Chapter is intended to give an introduction to the study of stresses in framed structures in order to assist the reader who has not had the opportunity to study this section of elementary mechanics. It is a preparation only for the special consideration of framed structures given in Vol. III.

209. When a structure is formed by assembling a series of comparatively narrow members by joints and straps, or by pins or bolts, to a triangulated outline, as described and illustrated in the application to roof trusses and partitions, the members of the frame become active transmitters of force in the direction of their length.

To do this satisfactorily and without causing a tendency to rotate at the connections, the axes of the members must intersect at a common point, and, strictly, should be connected by a single pin which would allow each member to move in the plane of the frame as it strains and causes change of length, and buckles under its load.

210. Practical conditions of truss jointing. In roof trusses and partitions made of timber it is impracticable to make the joints with pinned connections and in many cases the junctions cannot be arranged for axial intersection[1] of the members; hence, the following methods of analysis do not apply except as a rough approximation.

In steel trusses pinned connections can be easily arranged, but they are frequently expensive and are therefore not in great demand except for high class architectural steelwork; most commercial structures have their joints riveted and the centre lines of their members made approximately to intersect at a point, hence, while the joints are somewhat rigid they allow the members to communicate their forces directly through the point of intersection with a fair degree of accuracy.

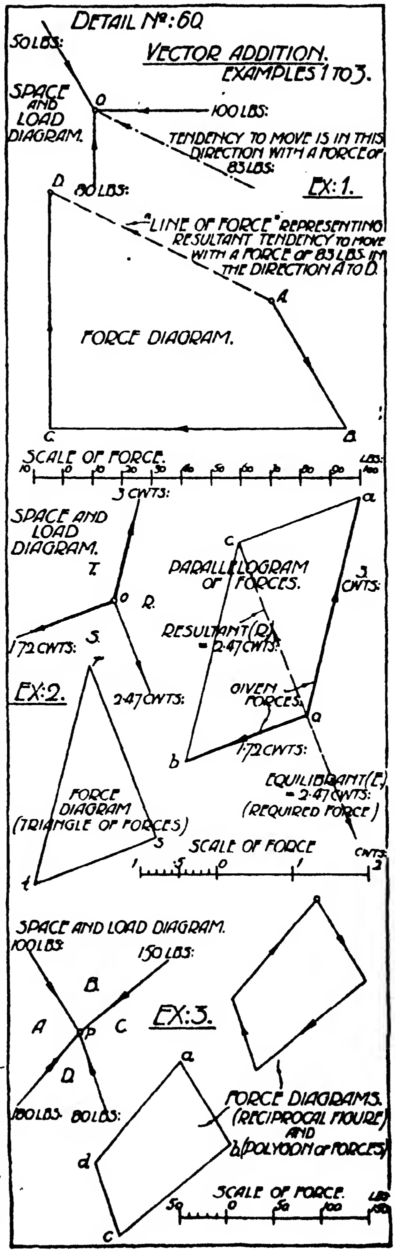
211. Principles of assessing forces in bars of framed structures. Assuming pin jointed connections the principles of vector addition may be employed for determining the forces in given lines.

Vectors are "directed" quantities, *e.g.* a force acting in a given line and

[1] Axial intersection strictly refers to intersection of lines passing through the centre of gravity of the cross section.

in a defined direction is a vector quantity. The laws of vectors show that when any number of forces act through a common point and in defined lines, so that the lines lie in one plane, their total effect to cause motion may be assessed by adding the quantities, using scalar lines to represent their magnitudes; these lines may be placed end to end in any order, but in the same direction as the forces. If the sum of such quantities is zero, there is no tendency to move, and this condition occurs when the end of the last vector line joins on to the point of commencement of the first vector.

If the initial and final points *do not coincide* there is a tendency to move which is represented by the length and direction of the line joining the first point to the last. The magnitude of the equivalent moving force is the scalar distance between the points, measured to the same scale as that employed to set out the diagram.



212. Vector addition. Detail No. 60, example 1, illustrates the process. Three forces, respectively 50, 100 and 80 lbs., are shown by full lines acting inwards through the point O, as indicated by the arrow-heads. Think of these force lines as contained in the plane of the paper; the diagram representing their position in space and indicating the magnitudes of the forces is known as the space

and load diagram, and will be seen later to be a convenient term for a loaded frame. We desire to know the effect of the three forces on the point O.

In the lower figure commencing at A, the three lines AB, BC and CD are made respectively 50, 100, and 80 units long to the selected scale, and have their directions identical with the force lines in the space figure. If D had coincided with A, the three forces would have been balanced—or in equilibrium—about O; but the distance AD on the lower diagram shows a scalar length of 83 units, viz. a tendency to move in a direction A to D with a force of 83 lbs. This force is called the "resultant" of the series, and acts through the point O; the *resultant* of any series of forces is that single force which could replace the others and produce exactly the same loading effect and tendency to motion; the resultant of a series of forces has the same moment as that series about any point in space.

The process of placing the vector quantities end to end in order to determine whether equilibrium exists is called vector addition.

213. Resultant and equilibrant. If the force of 83 lbs. represents the resultant tendency to move in a given direction, the tendency can only be stopped by applying an *equal and opposite* force through the point O; such a force is called the *equilibrant* of the series and may be applied in this case either as a push on the opposite side of O and meeting the resultant or as a pull on the same side as the resultant.

The diagram of vector addition is known generally as a "force diagram", because it represents the magnitudes and directions of the several forces which are added or compounded to assess their effect. It is also known as a "reciprocal diagram", each line being reciprocal in direction to the force lines of the space figure.

These diagrams are also particularly named according to the number of forces involved, *e.g.* "triangle of forces" when only three forces are in equilibrium, and "polygon of forces" if more than three in number.

214. Triangle of forces. Example 2 of the same detail shows three forces which are in equilibrium, and introduces a convenient method of naming the forces which is known as Bow's notation.

In the space diagram, the angular spaces are lettered and the forces are referred to by the letters on each side of the line. While the forces may be added in any order without affecting results, it is convenient and conducive to rapid routine work to decide upon a definite order of addition. A clockwise order of reference and addition of the forces has been adopted, and therefore in this case the upper force must be referred to as TR and not RT,

the left hand force as *ST* and not *TS*, and the lower force as *RS*, not *SR*.

This procedure makes it possible to utilise the same letters on the force diagram for the purpose of indicating the *direction* of the force as well as merely naming it. Thus, in the force diagram below the force *TR* is represented by the parallel line *tr*, being 3 cwts. to scale, *and in the clockwise order of reading* is lettered in the direction of action, viz. *from t to r*; then *rs* is added from *r* in the direction shown by *RS*, again read clockwise and, finally, *st* is added from *s* in the direction of *ST* in the space figure. The triangular force diagram *closes* and indicates that the three given forces are in equilibrium about *O*.

If two forces were given acting through a point, as for example those shown by the thick force lines of example 2, the third force (to produce equilibrium) may be determined in magnitude and direction by the previous principles, adding the given forces to scale, as before, and deciding the value and direction of the third force which will complete the force diagram. Thus, if *ST* and *TR* are known, we can draw *st* and *tr* as two sides of the force triangle, agreeing in direction when read clockwise; the third side, *rs*, represents the only force which can *close* the force diagram, and it must act from *r* to *s* which reads *downwards*. Hence, the required force would be *RS* as originally used.

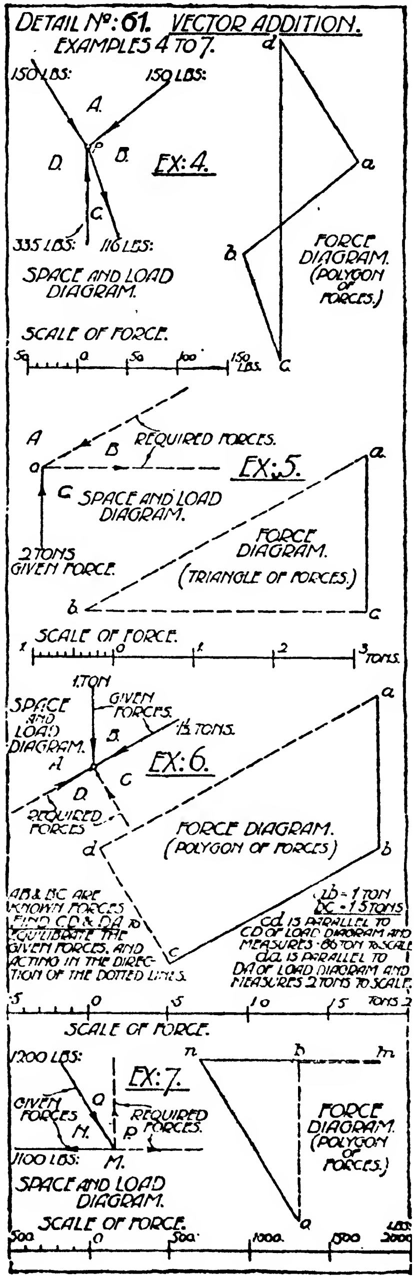
215. Parallelogram of forces. To the right of this example a different procedure is illustrated. Instead of drawing a separate force diagram, the magnitudes of the two given forces are scaled along their respective lines as at *Oa* and *Ob*. A parallelogram *Oacb* is then drawn on *Oa* and *Ob*, the diagonal of which, passing through *O*, represents the direction and magnitude of the *resultant* force. The *equilibrant* is equal in magnitude and opposite in direction as shown by the dotted line on the lower side of *O*.

On examination it will be seen that the left hand half of the parallelogram is identical with the triangle of forces in the same figure; either method of solution should be employed as may be found most convenient.

216. Polygon of forces. The polygon of forces constructed for a series of four inward forces in equilibrium is shown in example 3 of the same group. Two such polygons are drawn with their sides respectively parallel to the given lines of force in the space diagram and correctly scaled to represent them. In the upper figure arrows are used to indicate the order and direction of the addition; in simple examples for first consideration, this procedure is both clear and feasible. It should not, however, be developed as a *method* because in framed structures both ends of each member have to be

dealt with and employed in the same line of the force diagram for both ends. There would then be two sets of arrows on the diagram, tending to confusion. Hence, Bow's method is adopted, as shown in the lower figure, reading clockwise round the space diagram and making the lines of the reciprocal force diagram to correspond in direction with those of the space figure, and to agree in the order of reference.

Detail No. 61, example 4, shows a set of four balanced forces in which the directions are not all towards the point P, one of them being reversed to pull outwards. The force diagram is again reciprocal: DA acts downwards, hence da corresponds; AB acts inwards, therefore ab is added in the same direction from a to b; BC acts downwards, hence bc is added downwards from b; CD acts upwards and cd is added in this direction. The figure closes, hence the four forces are in equilibrium.



217. Circuital reading of force diagrams. It should now be clear that *when equilibrium of a series of forces occurs the added vectors form a complete circuit* from the point where the addition commenced, back to the same point.

From this knowledge the direction of action of a force can be determined inwards or outwards—push or pull—by noting its *direction in the force*

diagram when the order of lettering agrees with the clockwise reading of the force in the space diagram.

218. Determination of two unknown magnitudes and directions. Let three or more lines of force act at a point. If two of the forces are unknown in respect of their magnitudes and direction of action, while the other forces are *fully* known, the two unknowns can be solved if the lines in which they act are defined. This problem occurs constantly in the solution of forces in framed structures.

Example 5 illustrates the case of three forces, acting through a point, one being fully defined and the other two having their lines of action known.

In the force diagram, *ca* is set upwards to represent the known force *CA*, then *ab* to represent the general direction of *AB*; as *b* is known to be on a line parallel to *BC* a parallel line is drawn from *c* to meet *ab* in *b*, thus completing the triangle. To determine the direction of action of *AB* and *BC* commence the circuit of the force polygon at *c* and follow the initial direction *ca*; *ab* follows and reads downwards, hence *AB* pushes towards the point *O*, while *bc* reads from left to right showing that *BC* pulls away from the point in that direction. The arrows on *AB* and *BC* have been added after the solution has been obtained.

Examples 6 and 7 illustrate the method of solution for two similar unknowns where a total of four forces act through a point and should be clear from the principles explained for example 5.

In example 7 two of the forces act in the same straight line and would strictly overlap in the force diagram from *m* to *p*.

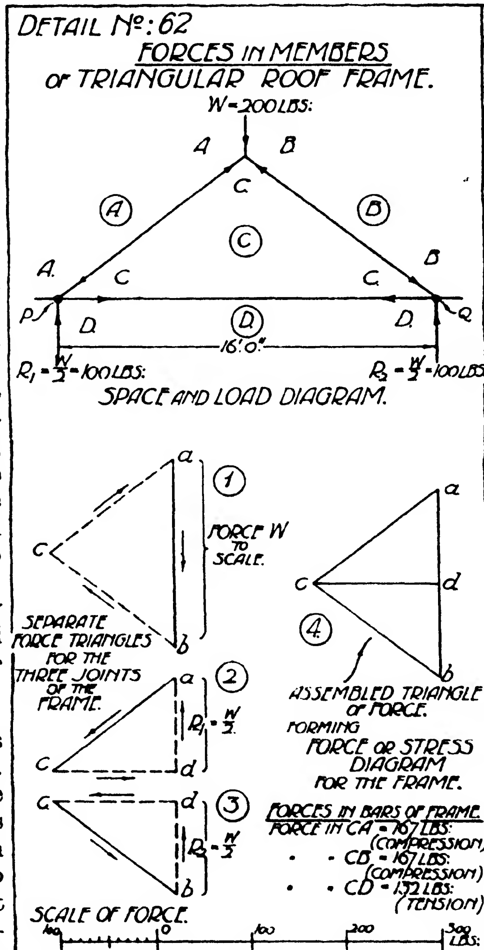
By direct application only two unknowns can be solved in any similar problem. The unknowns may be *magnitudes*, or *lines of direction*, but not both, and the solution of the former problem is sufficient for the present purpose.

219. Framed structures with pin joints. Let a framed structure, such as a simple triangular roof frame, rest upon two supports, *e.g.* brick or stone walls, steel stanchions or cast iron pillars, and let a load be placed upon the apex of the frame such as would be transmitted by a ridge resting upon it; see detail No. 62.

The weight *W* is transmitted through the frame to the two supports in exactly the same ratio as would occur if the load rested upon a beam of the same span and in a similar position between the supports. Thus, if *W* be central between *P* and *Q* the reaction at each support will be $\frac{W}{2}$, but if the load be out of the centre dividing the span into segments *a* and *b*, either reaction may be found by

taking moments about the other support or by using the rule deduced in Vol. III in regard to beams. By this rule

$$R_1 = \frac{Wb}{L} \text{ and } R_2 = \frac{Wa}{L}.$$



In a simple triangular frame it is unnecessary to calculate these reactions (see next paragraph) but in more complicated frames consisting of two or more triangles it will generally be necessary as a first operation to decide the forces at the supports; also, so long as the external forces are gravitation loads they will act vertically and the reactions will be vertical, but if other forces are applied to the frame in an inclined direction the reactions will no longer be vertical.

For the present, only vertical loads or dead weight forces will be considered.

220. Solution of forces in triangular frame. Consider the head of the frame. The two rafters which meet here can convey the force W to the supports by direct opposition in the direction of their length; they become lines of force. There are thus three force lines meeting at the point and the triangle of forces can be applied to find the two unknowns.

Letter the spaces between the force lines with any convenient

letters. Set down the known force AB to scale in the force diagram No. 1 at ab; from b add a line in the direction of BC which will terminate at an unknown point c somewhere on the line; to determine c and knowing that ca must be parallel to the bar CA, draw backwards from a at the given inclination to intersect the line from b at c. Then abc is the triangle of forces for the head of the frame; b to c and c to a are the directions of action of the forces in the corresponding bars and the lengths bc and ca are the magnitudes of the forces. Mark the direction of the forces so determined by arrows on the bars near the point of assemblage at the head of the frame.

It should now be clear that if the rafters offer resistance to W at the head of the frame they can only continue to do so if the opposite ends of the rafters will bear the force exerted, hence, there must be an equal and opposite force in each rafter acting at its foot. Arrows indicating this effect at the support may therefore be placed near the joint.

Suppose the reactions to be unknown there would be two unknown forces but in known lines at each support, viz. a horizontal one in the direction of the base (or tie) of the frame and the necessary vertical reaction. Another application of the triangle of forces will solve the unknowns.

For this purpose the letters A and C may be used for the same spaces as before—rewritten in the spaces near the left hand support for clearness—and another letter, say D, added in the space between tie and support.

Using a separate diagram, No. 2, set out the known force in the bar AC at ac. Reading clockwise add a line in the direction of CD from c and determine point d by dropping a vertical line backwards from a to meet the horizontal at d. Then cd is the force in the tie and reads as a pull to the right, while da is the reaction and reads upwards as a thrust towards the support. Arrows may now be added near the point of assemblage of the members as before to indicate the direction of the forces.

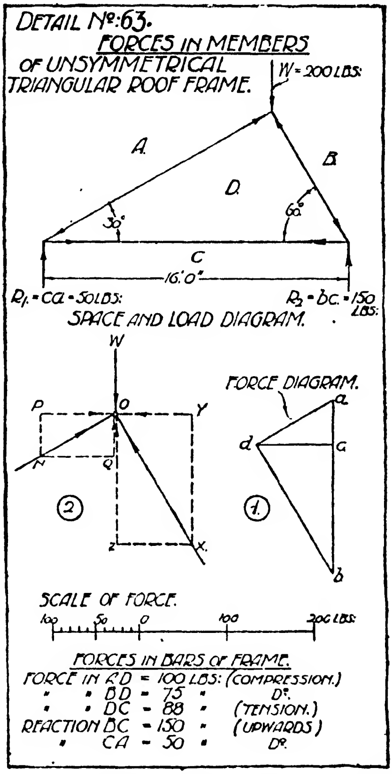
A similar triangle is drawn for the right hand support at diagram No. 3 and the direction arrows added.

221. Force or stress diagram. It will now be shown that the three separate force triangles just described may be assembled in one force diagram.

Commencing with the lettering of the frame, it is unnecessary to letter the spaces near each end of the bars; one letter in each space between bars and forces will suffice, as seen within the circles in the space and load diagram. Then, commencing at the head, set down the known force ab and draw the triangle of forces abc for this point, as in diagram No. 4. Consider the left hand point of support; using

the force line *ac*, already obtained as the known force, complete the triangle *acd* by drawing horizontally from *C*. This corresponds exactly with the separate triangle of diagram No. 2, but is superposed on the first triangle of forces. Similarly use the force line *cb* for the known force at the right hand support and complete the triangle *cbd*. It happens to be already determined, *bd* being the only force not previously noted, and necessarily equal to the difference between the reaction *da* and the whole load *ab*.

To determine the directions of the forces acting at any point of assemblage, read clockwise round the point in the space figure and note the direction of movement in the force diagram. If the direction of reading be maintained clockwise, the two ends of any member read in opposite order; thus, at the head the left hand rafter reads *CA*, but at the foot the same member reads *AC*. The fact that the ends must supply force in equal and opposite directions is therefore allowed for in the method of lettering and thus permits *one assembled diagram of force* to be used, avoiding the repetition of lines which occurs when separate force diagrams are employed.



A similar "force diagram" is shown for the irregular frame in detail No. 63, diagram 1; the reactions for this case should be calculated by moments and compared with the values of the lines *bc* and *ca* in the force diagram.

222. Resolution of forces. Consider the forces at the head of this frame. The load *W* is supported by the thrusts in the rafters, the greater part being transmitted to the support *BC* through the member *BD*.

To realise the amount of *vertical* load which is transmitted, the force in the bar may be *resolved* as follows into *horizontal and vertical components*. Thus, let the force in *DB* be set off along the line *O* to *X* in diagram No. 2; conceive this as the resultant force

due to two forces, OY, horizontal, and OZ, vertical, acting at O; the values of these equivalent forces are obtained by drawing the parallelogram $OYXZ$. Then OY is the horizontal component and OZ the vertical component of the force OX and could take its place with the same effect. OZ is the useful effort of OX to support the vertical load, and OY is the effort wasted by pushing horizontally and is due to the inclination. If the same process be applied on the rafter at ON, it will be found that $OZ+OQ=$ the load W, and $OY=OP$, therefore the horizontal components balance one another. It should be noticed that the force ON is *proportionately greater than the force OX, for the amount of vertical load which it supports.*

From these considerations it will be evident that the more nearly vertical a member can be placed, the more efficiently will it support vertical load.

Flat pitched roof trusses suffer in this respect, but on the other hand they have less roof surface and therefore less dead weight to carry and also offer less resistance to wind.

CHAPTER ELEVEN

PERMANENT CARPENTRY

Timber Floors and Roofs

Before detailing the construction of timber floors, it is necessary to give a summary of that part of the Model Bye-laws which refers to timber entering party walls and its contiguity to flues, as commonly occurs in floor construction.

223. Timber entering party walls. The Bye-laws require that timber joists, etc., shall not be nearer than $4\frac{1}{2}''$ to the centre line of the party wall, this provision having in view the prevention of the spread of fire from one building to another.

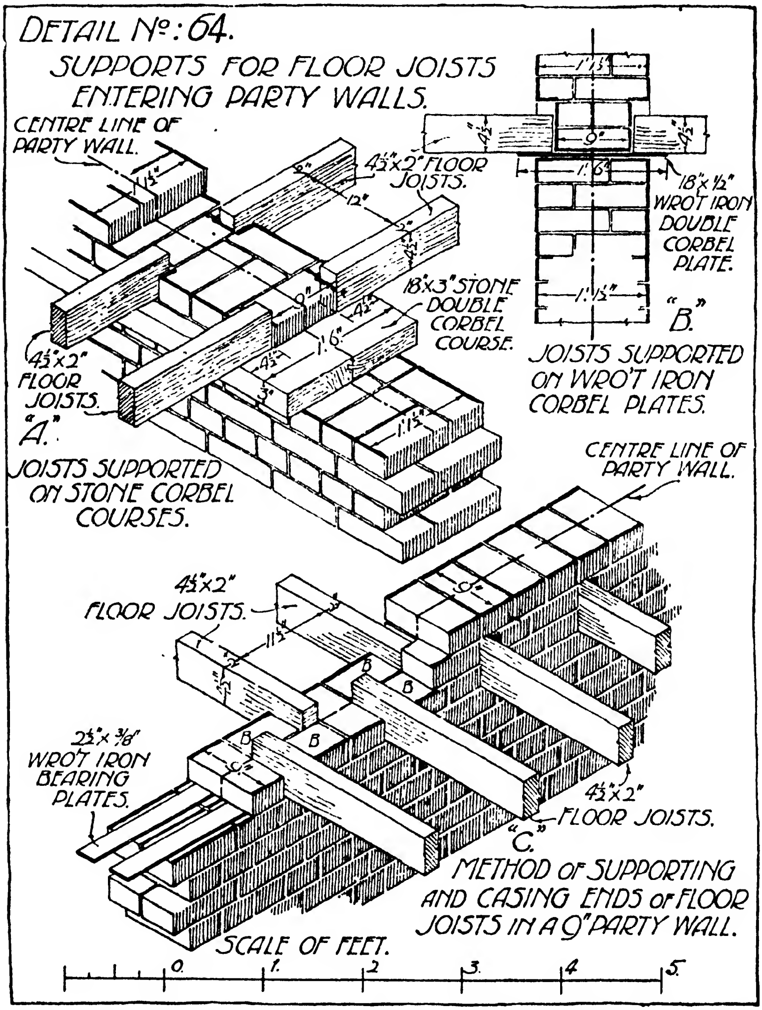
It is obviously impossible to support timbers upon and within such a wall, to give a $4\frac{1}{2}''$ bearing, unless the wall is 18″ thick, but, as most party walls for dwelling-houses are 9″ thick and seldom more than $13\frac{1}{2}''$, special methods of supporting such timbers are necessary.

In 9″ walls the most convenient method is to use a brick corbel course or to support a wall plate upon W.I. corbel pins, so that the joists do not enter the wall; see Vol. I. If $13\frac{1}{2}''$ walls are employed, $2\frac{1}{4}''$ of wall hold is obtainable and a single $2\frac{1}{4}''$ corbel course, or two $1\frac{1}{8}''$ courses, would extend the bearing to $4\frac{1}{2}''$. It will be seen that both these methods cause unsightly projections within the rooms below, but it may sometimes be possible to cover these with a plaster cornice.

In some districts special courses of stone slabs or of W.I. plates are allowed as alternatives and are wide enough to overhang $2\frac{1}{4}''$ beyond the faces of the party wall on each side, as shown in detail No. 64 at A and B. A further alternative method is allowed by the Bye-laws for 9″ party walls; this provides for a $4\frac{1}{2}''$ casing of brick or other incombustible material and the detail at C shows the method employed. Joists rest $4\frac{1}{2}''$ upon the wall, thereby reaching but not passing its centre line, and a header brick is placed between them while bats, BB, regulate the spacing. The method is quite satisfactory as regards the object in view, but causes interference with the spacing of floor joists.

224. Timber near flues. To meet the requirements of the Bye-laws, which in this connection stipulate that no timber must be within a distance of 9″ from the inside of any flue, nor nearer than

2″ to a 4½″ flue wall unless it be plastered, it would be necessary to trim any floor joists—which in the ordinary course would transgress



these regulations—in a similar manner to the trimming for a fire-place hearth.

Although it is often necessary and convenient to support timbers upon party walls, such an arrangement should be avoided, if possible.

225. Floor construction. Vol. I dealt only with "single" floors, viz. those having one series of timbers which support the flooring and also the ceiling where required. These floors should be limited to spans of about 16 ft., being uneconomical and lacking in rigidity if the timbers are unsupported over a greater length. For even less spans it is often wise to employ two sets of supporting timbers; the floor is then known as a *double floor*.

226. Principle of construction of double floors. When the span of a floor becomes too great for single timbers, some intermediate support is necessary; it may be provided by a large member placed at right angles to the joists and either wholly or partially below them; this, in its turn, receives support from the walls running parallel to the joists. This member is called a *binder* and should generally be placed across the shorter span of the room; it differs from a trimmer in that the latter has the same depth as the joists bearing upon it.

Binders may be of timber, or steel, or a combination of the two materials; rolled steel sections are in common use to support timber joists in floors of large span.

The purpose of a binder is clearly to *shorten the effective span*[1] *of the joists*, thus enabling smaller timbers to be employed for this purpose and so economise material and space.

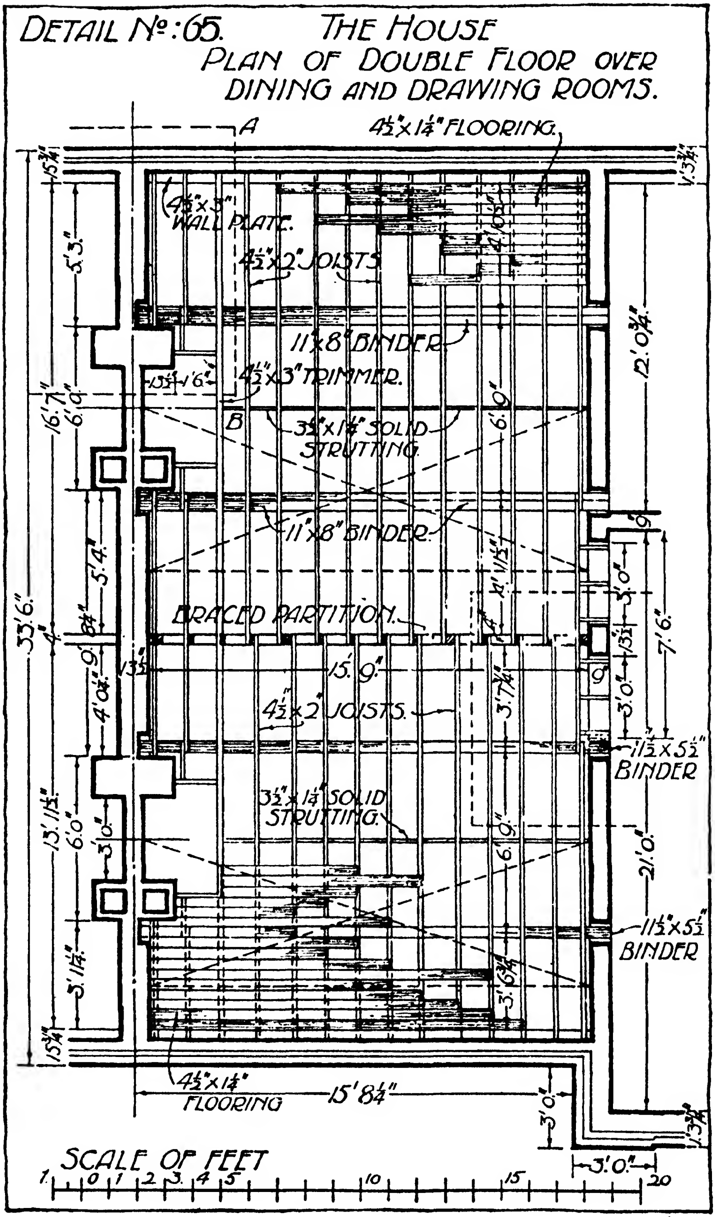
Joists in double floors are usually notched from half to three-quarters of their depth into the binder, when of timber, or over its top flange when of steel. This practice reduces the projection of the binder below the ceiling, but a stronger floor is obtained by retaining the full depth of the joists and resting them directly upon the binder.

Floors of Semi-Detached House

227. In the house there are two large rooms on the ground floor serving as dining and drawing rooms with bedrooms of the same size immediately above. The bedroom floors are both arranged as double floors, but show alternative methods of construction; see details Nos. 65, 66 and 67.

The dining room is 15′ 9″ × 14′ and the drawing room 15′ 9″ × 16′ 7″ and in flooring over these, the binders are placed across the 15′ 9″ span, because the appearance of the room is improved by dividing it into three bays, the centre one enclosing the chimney breast, with the binders close to the sides of the latter. Further, these rooms are divided by a braced timber partition passing through two storeys—from ground to attic floors—which is not convenient for supporting binders.

[1] See Vol. III.


DETAIL No: 65.
THE HOUSE
PLAN OF DOUBLE FLOOR OVER DINING AND DRAWING ROOMS.
A
B
FLOORING.
WALL PLATE.
JOISTS.
11"x8" BINDER.
TRIMMER.
SOLID STRUTTING.
11"x8" BINDER.
BRACED PARTITION.
15' 9"
JOISTS.
BINDER
SOLID STRUTTING.
BINDER
FLOORING
33' 6"
12' 0¾"
21' 0"
7' 6"
6' 0"
SCALE OF FEET
10
15
20

Detail No. 65 shows the disposition of the timbers in the bedroom floors over the dining and drawing rooms; the portions further detailed are enclosed in the dotted rectangles on the plan.

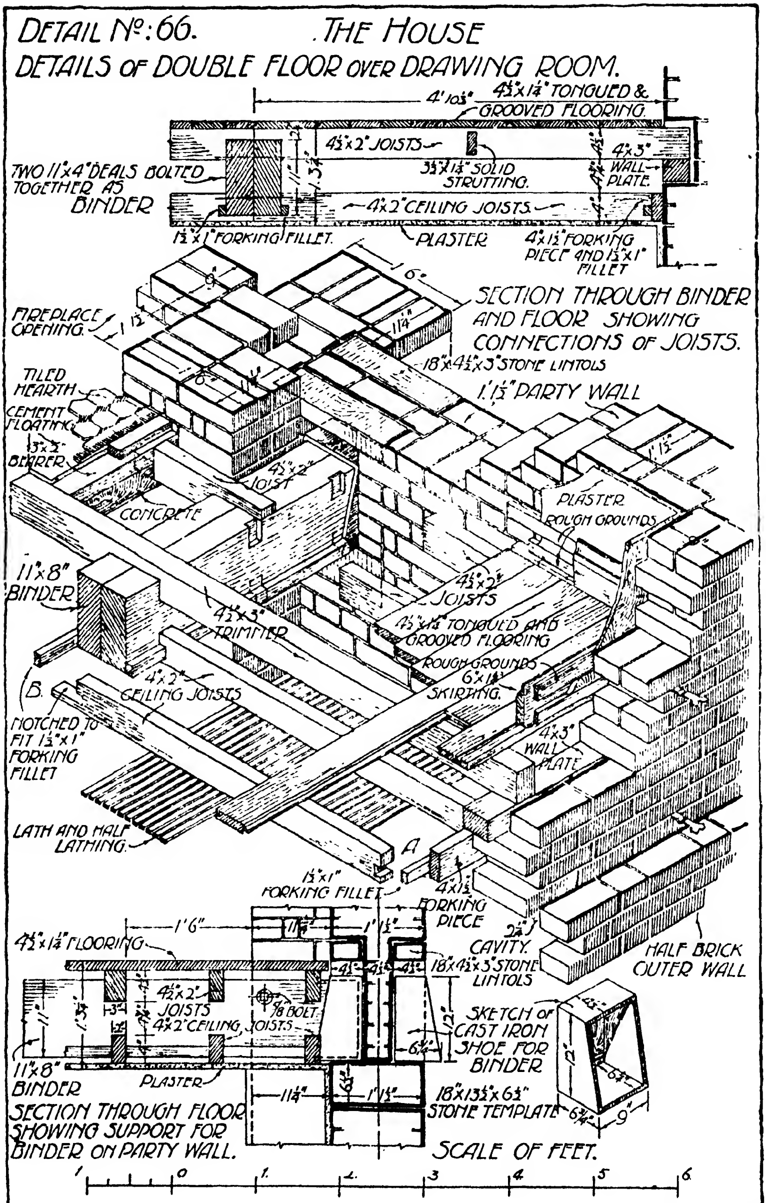
228. Floor over drawing room. The joists of this floor are $4\frac{1}{2}'' \times 2''$ resting upon the front wall at one end and upon the head of the braced timber partition at the other, and also at two intermediate points upon timber binders; the latter are $11''$ deep $\times 8''$ wide, and are obtained by using two $11'' \times 4''$ sawn timbers and bolting them together as shown in detail No. 66. Each binder may be placed within $2''$ of the chimney breast and must have a bearing of $6''$ or more at each end; bearing surfaces are provided by stone templates $13\frac{1}{2}'' \times 9'' \times 6\frac{1}{2}''$ thick, the thickness being necessary to obtain the correct levels for the bearings. At the party wall, templates are often allowed to pass through the wall and to receive the ends of two sets of floor timbers.

229. Use of cast iron boxes at party walls. At the party wall between the houses a difficulty occurs in providing the necessary bearing, because the Model Bye-laws and many Local Bye-laws require that no timber shall pass nearer than $4\frac{1}{2}''$ to the centre of a party wall.

In some cases the difficulty may be overcome as shown by detail No. 66, in which the ends of the binders reach to within $2\frac{1}{4}''$ of the centre of the wall and are enclosed by cast iron boxes $\frac{1}{2}''$ thick, the sides of which project in front of the wall face and effectively check the possible spread of fire from building to building, besides providing a $6\frac{1}{4}''$ bearing for the binder. This is a satisfactory provision though not accepted by all local authorities.

A pocket is formed in the brickwork and is spanned by a $3''$ stone lintol, in order to receive the ends of such binders built into the wall, and in the case of timber beams not encased in cast iron shoes there should be a space around and at the back so that adequate circulation of air is ensured, which assists in preserving the timber. It is also wise not to fix cast iron boxes too closely.

230. Use of corbels at party walls. Where cast iron boxes may not be employed an alternative method is to use a moulded stone corbel projecting $4''$ or $4\frac{1}{2}''$ into the room and passing through the full thickness of the party wall; a bearing of $6''$ could then be obtained without transgressing the Bye-laws referred to. Should two binders or beams occupy similar positions on opposite sides of the party wall —as in the case of semi-detached houses—one large corbel may serve for both bearings. The only objection to this method is the possibly unsatisfactory design and treatment of the corbel and its surrounding features.


DETAIL No: 66. THE HOUSE
DETAILS OF DOUBLE FLOOR OVER DRAWING ROOM.
4'10½"
4½"x1¼" TONGUED & GROOVED FLOORING
4½"x2" JOISTS
3½"x1¼" SOLID STRUTTING
4"x3" WALL PLATE
TWO 11"x4" DEALS BOLTED TOGETHER AS BINDER
4"x2" CEILING JOISTS
1½"x1" FORKING FILLET
PLASTER
4"x1½" FORKING PIECE AND 1½"x1" FILLET
SECTION THROUGH BINDER AND FLOOR SHOWING CONNECTIONS OF JOISTS.
FIREPLACE OPENING
TILED HEARTH
CEMENT FLOATING
3"x2" BEARER
18"x4½"x3" STONE LINTOLS
1'1½" PARTY WALL
CONCRETE
4½"x2" JOIST
PLASTER
ROUGH GROUNDS
11"x8" BINDER
4½"x3" TRIMMER
4½"x2" JOISTS
4½"x1¼" TONGUED AND GROOVED FLOORING
ROUGH GROUNDS
6"x1¼" SKIRTING
4"x2" CEILING JOISTS
B.
NOTCHED TO FIT 1½"x1" FORKING FILLET
4"x3" WALL PLATE
LATH AND HALF LATHING
A
1½"x1" FORKING FILLET
4"x1½" FORKING PIECE
2½" CAVITY
HALF BRICK OUTER WALL
4½"x1¼" FLOORING
1'6"
1'1½"
4½"x2" JOISTS
⅞ BOLT
4"x2" CEILING JOISTS
18"x4½"x3" STONE LINTOLS
SKETCH OF CAST IRON SHOE FOR BINDER
11"x8" BINDER
PLASTER
18"x13½"x6½" STONE TEMPLATE
SECTION THROUGH FLOOR SHOWING SUPPORT FOR BINDER ON PARTY WALL.
SCALE OF FEET.

A very obvious method of increasing the bearing of these binders will present itself to the student, *i.e.* to construct an attached brick pier in the angle of the recess on each side of the chimney breast, and this method is illustrated in the detail of the dining room fireplace, in Vol. III.

231. Connection of floor joists to binders. The main part of detail No. 66 shows the angle of the chimney breast in isometric projection with the binder and cast iron box in position and with the joists fitted to the binder and trimmed round the fireplace. The $4\frac{1}{2}'' \times 2''$ joists run parallel to the chimney breast at 14″ centres and have a maximum span between the binders of 6′ 1″; calculations given in Vol. III show that the joists are sufficiently strong and rigid for their work, even if considered as discontinuous over the three spans, though continuity adds to their strength and stiffness.

Joints between joist and binder are cogged, having in this case a depth of 3″ and being cut inwards 1″ from the faces of the girder to provide ample bearing.

At the fireplace a $4\frac{1}{2}'' \times 3''$ trimmer is employed, upon which the concrete hearth is partly supported.

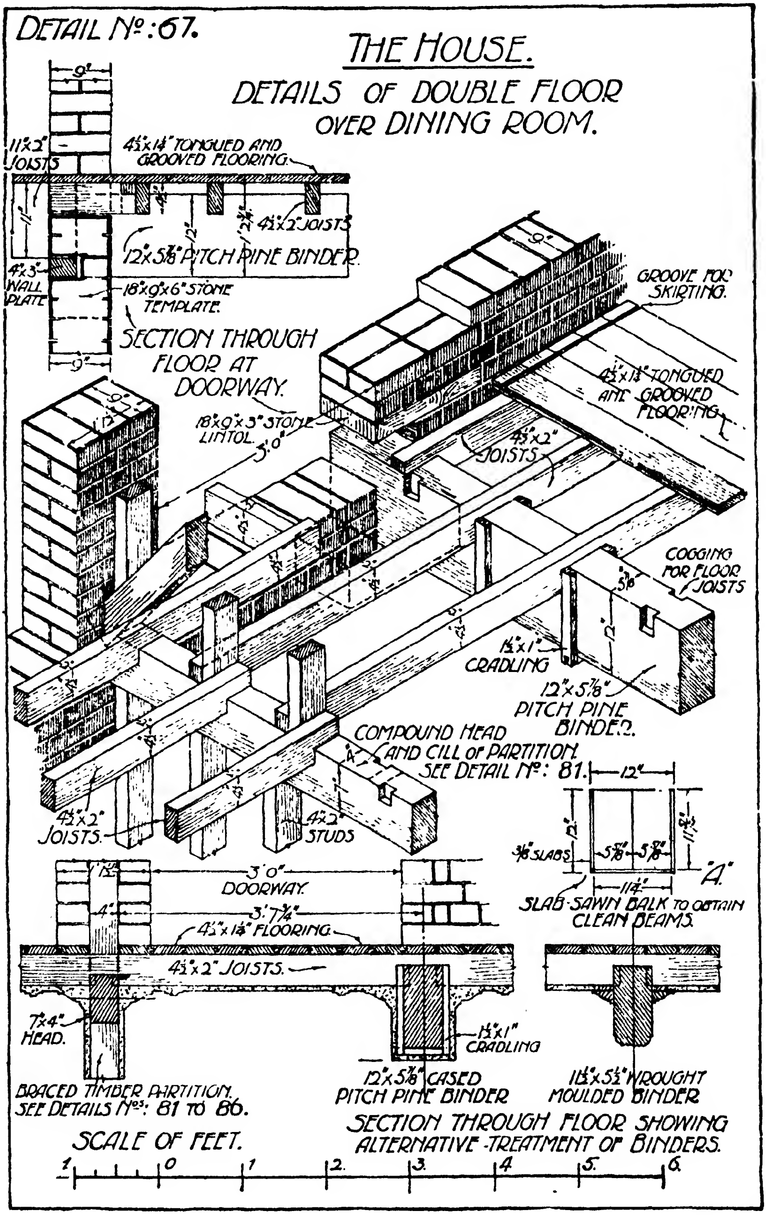
232. Floor over dining room. The floor over the dining room is shorter than the one just considered, but this only affects the length of the joists because the span of the latter between the binders is the same, while the side spans are shorter than those of the drawing room; $4\frac{1}{2}'' \times 2''$ joists may therefore be employed as before.

The dimensions of the binder have been selected in order to allow two $11\frac{1}{2}'' \times 5''$ pieces to be cut out of a square log, as shown at A on detail No. 67. By the removal of $\frac{3}{8}''$ slabs from three sides and then "flitching" or cutting down the centre, the sides and soffit of each beam have clean surfaces ready for dressing and moulding to form wrought beams, if these are desired as an alternative to cased beams as shown in section. These binders might suitably be either of oak or pitch pine according to the nature of the surrounding woodwork.

If the beams were to be cased they would be flitched directly from the 12″ square log, the rough surfaces being no objection.

While the binders referred to are the least allowable sizes consistent with strength and stiffness, in high or wide rooms such thin beams would have a weak appearance and it may be desirable to use broader beams.

233. Floor strutting. The purpose and types of strutting were dealt with in Vol. I, and it only remains to call attention to its position on the plan in detail No. 65, and to suggest that in narrow joists such as these solid strutting has a distinct advantage.


DETAIL Nº: 67.
THE HOUSE.
DETAILS OF DOUBLE FLOOR OVER DINING ROOM.
11"x2" JOISTS
4½"x1¼" TONGUED AND GROOVED FLOORING.
4½"x2" JOISTS
12"x5⅞" PITCH PINE BINDER.
4"x3" WALL PLATE
18"x9"x6" STONE TEMPLATE.
SECTION THROUGH FLOOR AT DOORWAY.
18"x9"x3" STONE LINTOL.
GROOVE FOR SKIRTING.
4½"x1¼" TONGUED AND GROOVED FLOORING.
4½"x2" JOISTS.
COGGING FOR FLOOR JOISTS
1½"x1" CRADLING
12"x5⅞" PITCH PINE BINDER.
COMPOUND HEAD AND CILL OF PARTITION. SEE DETAIL Nº: 81.
4½"x2" JOISTS.
4"x2" STUDS
⅜" SLABS
"A"
SLAB-SAWN BALK TO OBTAIN CLEAN BEAMS.
3'0" DOORWAY.
4½"x1¼" FLOORING.
4½"x2" JOISTS.
7"x4" HEAD.
1½"x1" CRADLING
12"x5⅞" CASED PITCH PINE BINDER
11½"x5½" WROUGHT MOULDED BINDER
BRACED TIMBER PARTITION. SEE DETAILS Nos: 81 TO 86.
SECTION THROUGH FLOOR SHOWING ALTERNATIVE TREATMENT OF BINDERS.
SCALE OF FEET.

234. Ceiling to dining room. The ceiling over the dining room is panelled, the effect being obtained by attaching the flat plaster ceiling to the underside of the joists while the binders project below this surface. To screen these from view they are also clothed with plaster, which is attached to wooden laths supported by nailing to narrow pieces of timber framed at intervals of 12″ round the binder, as in detail No. 67. These frames are termed "cradling" or "firring", and their object is to pack the plasterers' laths away from the flat surfaces of the beam in order to allow the soft plaster to pass between and behind and thus obtain a "key" or "grip" upon them. See also in the chapter on Plastering, where further examples are given.

In the alternative arrangement where wrought beams are employed the ceiling might be formed with fibrous plaster slabs screwed to the soffits of the joists, treated as described under Plastering and finished against the beam and walls with a small wood cornice secured to the former and to rough grounds plugged to the latter.

235. Ceiling to drawing room. The ceiling over the drawing room is illustrated at detail No. 66 and shows a level surface which necessitates the use of a separate series of joists supporting the ceiling only, and named "ceiling joists". These members are of 4″ × 2″ fir, in short lengths, and are fixed after the floor is completed by forking the ends, as described in Vol. I and here illustrated. The wall ends are shown at A and the attachment to the binder at B; in the latter case the forking piece is nailed flush with the under edge of the binder and the ceiling joist allowed to stand $\frac{3}{4}$″ below it. This strip is made to overlap the binder to its centre, by which means the plasterer's laths are kept clear of the beam and a proper key for the plaster is obtained.

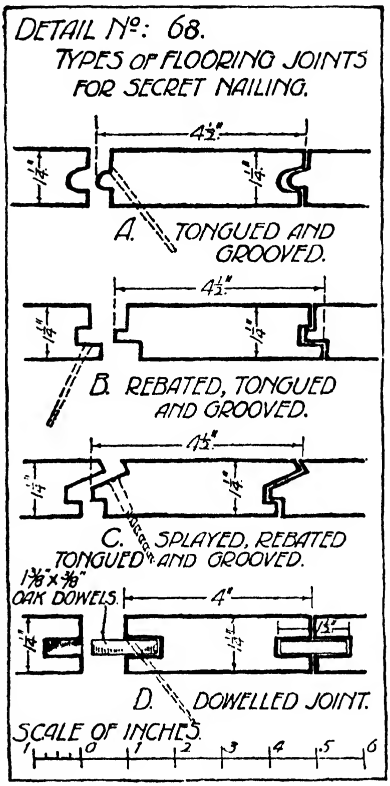
The isometric view shows the complete treatment of the timber framework and the student should note the cogged binder, notched joists, forking fillet, forked end of ceiling joists, flooring, lathing and support at the wall end.

236. Value of double ceilings. A particular advantage in the use of ceiling joists is that the deflection of the floor joists is not directly communicated to the plaster ceiling which is the case where ceilings are directly attached, and which may cause unsightly cracks unless rigid floor joists are employed.

The double joisted floor also possesses a greater resistance to the passage of sound from room to room through the timbers, because of the greater air space enclosed and the lack of continuity in the structure.

237. Edge joints in flooring. Ordinary flooring joints have been previously considered in Vol. I and included all those forms in which the boards were intended to be nailed through the exposed surface. It may, however, be desirable or necessary in some cases to avoid showing the nail holes, in which case some method of secret nailing is adopted. This applies most particularly to polished hardwood floors, and is sometimes applied to deal flooring.

Where hardwood is employed a common method is to nail through the angle of the tongue of the ordinary tongued and grooved joint, as shown at detail No. 68 at A, inclined holes being drilled during the preparation of the flooring so that nails may be easily driven and punched home. Such a method is best applied to flooring boards intended to be laid upon a continuous bed of breeze concrete where the nail holes would be spaced regularly at about 15″ to 18″ centres.



238. Joints for secret nailing in soft wood. Where soft wood flooring is desired to be secret-nailed to joists, the form of the joint should be suitable for allowing oval wire nails to be driven without boring holes to receive them, because holes at regular spacing would not be convenient for suiting the probable variation in the spacing of the joists. Methods suited to this purpose—and also equally suited to hardwoods—are illustrated in the above detail at B, C and D.

The form B is called a rebated, tongued and grooved joint; it is deficient in having too little material to provide a grip for the nail head. One great advantage, however, is the secure connection between the edges of adjacent boards, which cannot separately lift from their beds, even though the nails fail to hold them down solidly.

The form C is better than B if correctly proportioned, providing

an excellent hold for the edge nail (or screw), and effectively keeping the edges from lifting. It is called a splayed, rebated, tongued and grooved joint.

In faultily proportioned joints the one defect is lack of wearing thickness and the exposure of a sharp edge when the splayed rebate is worn down.

A dowelled edge joint is shown at D, where the edges are square and connected by $\frac{3}{8}'' \times 1\frac{3}{8}''$ oak dowels. Each board is also secured to the floor timbers by skew nailing through the outer edge of the board.

In all cases where edge nailing is adopted, narrow well-seasoned boards are imperative and they are preferably rift sawn as illustrated in Vol. I, with the annual rings practically normal to the wearing surface.

Hardwood boards are wisely kept to $4\frac{1}{2}''$ or less in width in order to provide nails at more frequent intervals, because the resistance required to prevent hardwood boards from warping is greater than with soft wood of similar size.

Further, wide boards, with their consequent shrinkage, destroy the effectiveness of the joints and spoil the appearance of the floor in addition to holding dirt in the open joints and tending to produce insanitary conditions.

239. Heading joints in flooring. In Vol. I the common forms of heading joint were explained, viz. square heading and splayed heading where the board ends are cut to rest upon one joist and nailed thereto.

In secret-nailed flooring special forms of heading joint are necessary. If jointed over joists or bearers, the ends are cut square and one or two dowels inserted endwise, similar to the illustration at D in detail No. 68. This prevents either of the boards lifting at the unnailed edge, which would destroy the planeness of the floor surface.

In some cases a joint is formed by hand, to match the edge joint; this is tedious and wasteful.

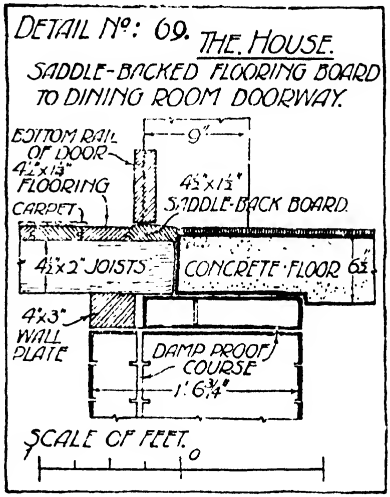
Another method, now little used, is to tongue the board ends together by a series of tapered vertical tongues, fitted neatly and tight, and glued together; this is known as a forked heading joint.

If the flooring is of hardwood to be nailed directly to breeze concrete,[1] the boards are specially prepared with return or heading joints tongued and grooved like the edges at A; such preparation is economical because the joints may occur anywhere in the length and thus boards of any odd length may be utilised without cutting or waste.

[1] See Chapter on Materials.

In first class soft wood flooring up to 16 ft. span heading joints should not be allowed.

240. Saddle-backed boards for doorways. The section in detail No. 69 shows the application of a raised board known as a "saddle-backed" board, for the purpose of lifting the bottom edge of a door to allow it to pass over a carpet; such a provision is necessary to avoid a wide space and consequent draught beneath the door.



A special form of hinge may be used for the same purpose. It is known as a rising butt.

241. Direction of flooring boards. In single floors where the bridging joists are placed across the shorter span of a room, the direction of the floor boards is naturally parallel to the longer side, and this tends to give an appearance of greater length to the room, thus adding to the architectural qualities of the apartment.

Where a double floor is used a little thought will show that this arrangement is impossible since the bridging joists run parallel to the length of the room. This defect can be remedied by counter-boarding, which consists of placing one layer of boards diagonally upon the joists and another layer in the desired direction and secured to the under or counter-boarding.

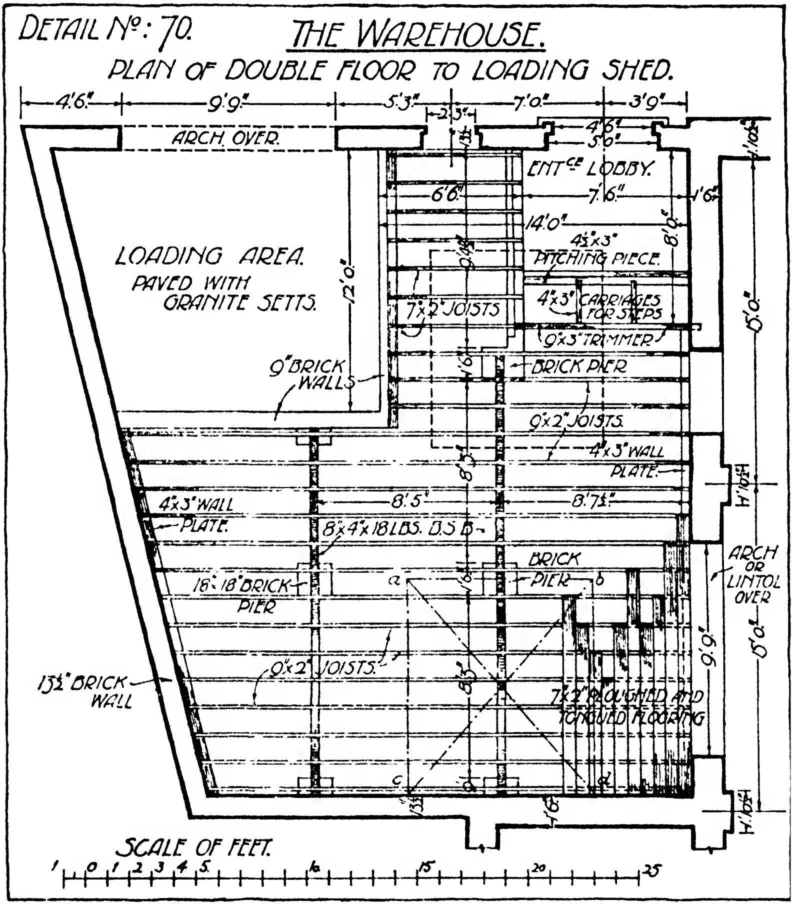
242. Framed floor. A further type of floor known as a framed floor has for one of its objects the elimination of the above-named defect by using three systems of timbers, so that the joists run in the short direction and the flooring is lengthwise of the room. The old type of timber framed floor is now almost entirely eliminated by the use of steel construction which allows the double floor type to be applied to large spans.

Warehouse Floors

243. Floors for heavy traffic or transport. Where a floor is to be used for heavy traffic or for the handling and transport of heavy goods, such as occurs in warehouses and workshops, ordinary flooring may be very unsatisfactory, as it is too thin to provide

for rough wear, although it may be initially strong enough. In these cases, when laid upon timber joists, $1\frac{1}{2}''$ to $2''$ flooring is required.

Selected Northern pine is generally employed in order to avoid the slipperiness common to hardwoods which become smooth and often glazed under friction.



Oak and teak are the best hardwoods because of their rough grain, while maple and birch wear exceedingly well and uniformly, but become slippery.

244. Loading shed floor of warehouse. The loading shed floor is an example of the provision for heavy wear.

Its form is irregular in plan, having one side splayed, and two

angular portions recessed out of it, one at the employees' entrance to form the stair well and the other to form a waggon-loading recess at the acute angle.

This double floor consists of steel binders which are carried upon brick piers and support timber bridging joists and 2" deal flooring. The general arrangement of the members is shown upon the plan in detail No. 70; the binders, by obtaining intermediate support from the piers, may be largely reduced in size while at the same time supplying a rigid structure.

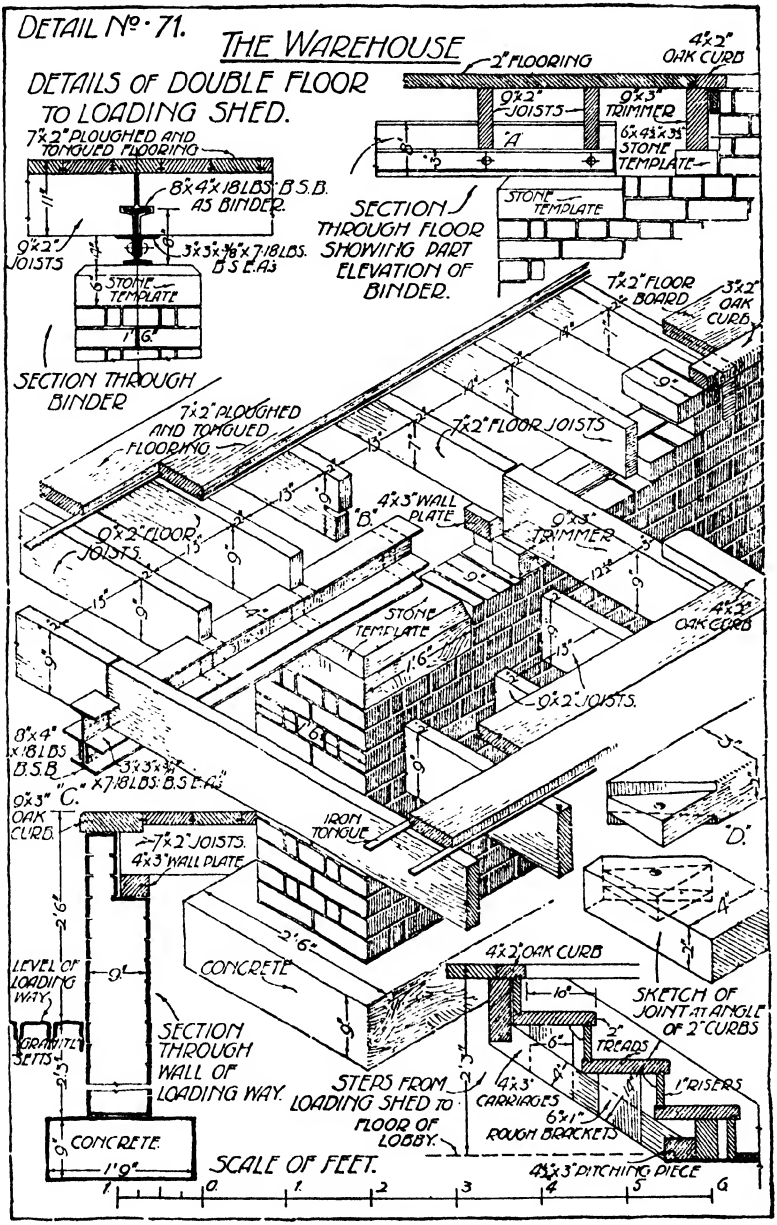
245. Use of standard steel sections in binders. Steel binders may be used with advantage in lieu of large timbers. Steel beams are most suitably of **I** section, selected from a series of British Standard Beams (B.S.B.'s) which are made by all British structural steel manufacturers. The strengths of these sections when used as beams are easily computed from their known properties, depending upon their shape and size and kind of material employed, and a suitable section may be selected for flooring purposes as explained in Vol. III. Steel beams are specified by stating their overall depth and breadth, and weight per ft. run, given in the order named and prefixed by B.S.B. if a British Standard Beam (see illustrations in Vol. I, and the appendices in Vol. III).

In this example, see detail No. 70, the binders have a clear span of 8′ 3″ between piers, or a centre to centre span of 9′ 4½″; and are B.S.B.'s 8″ × 4″ × 18 lbs. To support the timber joists while reducing the thickness (or depth) of the floor, steel angles are riveted to the web of the girder. These angles are also of standard shape and are described as British Standard Angles (B.S.A.'s). When the two arms of the angle are equal or unequal, the initial letters are introduced thus: B.S.E.A. or B.S.U.A. The full description includes the width of the two arms and the thickness of the metal, which is uniform throughout the section, except at the rounded angles; this thickness must always be stated, as various thicknesses are made to each set of overall sizes.

The example shows B.S.E.A.'s 3″ × 3″ × ⅜″ × 7·18 lbs. attached one on each side of the web, 4″ below the top edge of the girder.

The timber joists are 9″ × 2″, placed at about 15″ centres, notched over the top flange and thus projecting 5″ above the girder. The steel angles are secured by ⅞″ diameter rivets; these may, with advantage, be placed one beneath each pair of joists, producing a rigid support, as shown at A in detail No. 71.

Joists are often notched over the top flanges of girders exactly as shown at B, but without the supporting angles. This method serves satisfactorily for ordinary floors loaded up to about 1¼ cwts. per ft. sup. over the whole surface, but for warehouse work the joists


DETAIL No. 71.
THE WAREHOUSE
DETAILS OF DOUBLE FLOOR TO LOADING SHED.
7"x2" PLOUGHED AND TONGUED FLOORING
8"x4"x18LBS. B.S.B. AS BINDER.
9"x2" JOISTS
3"x3"x3/8"x7.18LBS. B.S.E.A's
STONE TEMPLATE
1'6"
SECTION THROUGH BINDER
2" FLOORING
4"x2" OAK CURB
9"x2" JOISTS
9"x3" TRIMMER
6"x4½"x3½" STONE TEMPLATE
'A'
SECTION THROUGH FLOOR SHOWING PART ELEVATION OF BINDER.
STONE TEMPLATE
7"x2" FLOOR BOARD
3"x2" OAK CURB
7"x2" PLOUGHED AND TONGUED FLOORING
7"x2" FLOOR JOISTS
9"x2" FLOOR JOISTS.
"B."
4"x3" WALL PLATE
9"x3" TRIMMER
4"x2" OAK CURB
STONE TEMPLATE
9"x2" JOISTS.
8"x4" x18LBS B.S.B.
3"x3"x⅜" x7.18LBS. B.S.E.A's
"C."
9"x3" OAK CURB.
7"x2" JOISTS.
4"x3" WALL PLATE
IRON TONGUE
"D."
CONCRETE
LEVEL OF LOADING WAY.
GRANITE SETTS
SECTION THROUGH WALL OF LOADING WAY.
CONCRETE
1'9"
4"x2" OAK CURB
SKETCH OF JOINT AT ANGLE OF 2" CURBS
2" TREADS
1" RISERS
4"x3" CARRIAGES
6"x1" ROUGH BRACKETS
STEPS FROM LOADING SHED TO FLOOR OF LOBBY.
4½"x3" PITCHING PIECE
SCALE OF FEET.
1 0 1 2 3 4 5 6

are liable to split along the notch under heavier loading or by momentary vibrations caused by dumping heavy packages upon the floor.

246. Flooring to loading shed. The flooring is prepared from 7″ × 2″ selected Northern pine battens, preferably rift sawn, and the edge ploughed for 1″ × $\frac{3}{16}$″ wrot iron tongues placed 1¼″ down from the wearing face. The material should be mature[1] wood, dry and well seasoned and secured by two 4″ flooring nails to each batten at each joist and well punched in.

Where the flooring terminates at the loading area a 9″ × 3″ oak curb is provided, having a bull-nose edge as at C. The floor joists are notched at the ends to receive the back edge of the curb, which is firmly screwed down to the joists and also bedded in mastic upon the outer half brick of the enclosing wall to the area.

A 4″ × 2″ oak nosing is provided as the top tread to the stair, and is joined to a 3″ × 2″ curb on the side of the well; the curb is dovetail mitred at the angle as shown in the detail at D. This joint prevents the surfaces twisting while securing the neat appearance of the mitre and ensuring a close joint; it may be pinned through the dovetail where the seasoning of the timber is doubtful or the support is not perfectly reliable. The use of the dovetail is to prevent the joint moving out of place while being driven home.

247. Construction of stair and adjacent floor. The stair and its support are illustrated in section.

The narrow portion of floor between the stair and loading area has a clear span of 5 ft. as against 8 ft. for the main bays of the floor, and 7″ × 2″ joists are found to be strong enough; these are laid as a single floor across the two 9″ walls.

At the head of the stair a 9″ × 3″ trimmer is placed and at the foot a 4½″ × 3″ pitching piece; between these members two 4½″ × 3″ rough carriages are jointed by birdsmouth notches and firmly spiked. The steps, being 7′ 6″ wide, require two sets of intermediate supports, which are provided by rough brackets nailed to alternate sides of the carriages, while the bottom step derives support from a 6″ × 3″ floor bearer laid on edge against the pitching piece at the base of the stair.

The floor of the lobby at the foot of the stair would be formed in concrete laid upon hard core as previously described.

[1] See Chapter on Materials.

Trussed Roofs in Timber

Steel roof trusses have already received consideration in Chapter Eight. The following paragraphs refer specifically to wooden roof trusses.

248. General arrangement of trussed roofs. When a building, or some portion of it, is longer than an average purlin can span, it is necessary either to employ specially strong purlins of rolled steel or to build up trussed purlins to the required strength, or again, to shorten the span of the purlins to suit their average dimensions, by inserting roof trusses in intermediate positions at right angles to the length of the building. These trusses—or principals—serve the same purpose as division walls, in providing support for the purlins. Their spacing, centre to centre, may vary from 8 ft. to 12 ft. under normal conditions, giving an average of 10 ft. centres, though special circumstances may call for either closer or wider spacing.

It is obvious that the strength of a truss must be varied according to the load it is called upon to bear, and that the load on any truss will vary directly with the spacing.

The form of truss adopted depends partly upon the span but more often upon the architectural or commercial purpose for which it is to be employed.

For churches, schools and public halls, or where there is no object in covering the framing, open roofs may be adopted, viz. roofs in which all the timbering is open to view; thus the nature of the truss would probably be ornamental in its conception. In many such buildings, however, a closed or ceiled roof may be desired in order to obtain a flat or segmental ceiling which is suitable for decoration in plaster work, for which purpose any well triangulated frame of a simple character may be adopted.

In factories, warehouses and commercial premises, where appearance is of secondary consideration, any suitable outline may be adopted which combines strength and rigidity, is economical in construction and adaptable to meet special circumstances. Very often the same forms are employed as would be selected for ceiled roofs.

249. Roof trusses for spans exceeding 30 ft. Previous studies have explained the construction of the king-post and king-bolt forms of truss, which are suitable for spans of 16 to 30 ft. These forms of truss have one strut providing support to the principal rafter immediately under the purlin, of which only one is generally employed.

For wider spans, say 30 ft. to 42 ft., two purlins on each slope are required, hence there should be two points of support provided for the principal rafter by the internal members of the roof truss. At

the same time, at least one additional point of suspension must be provided for the tie beam, to prevent sagging.

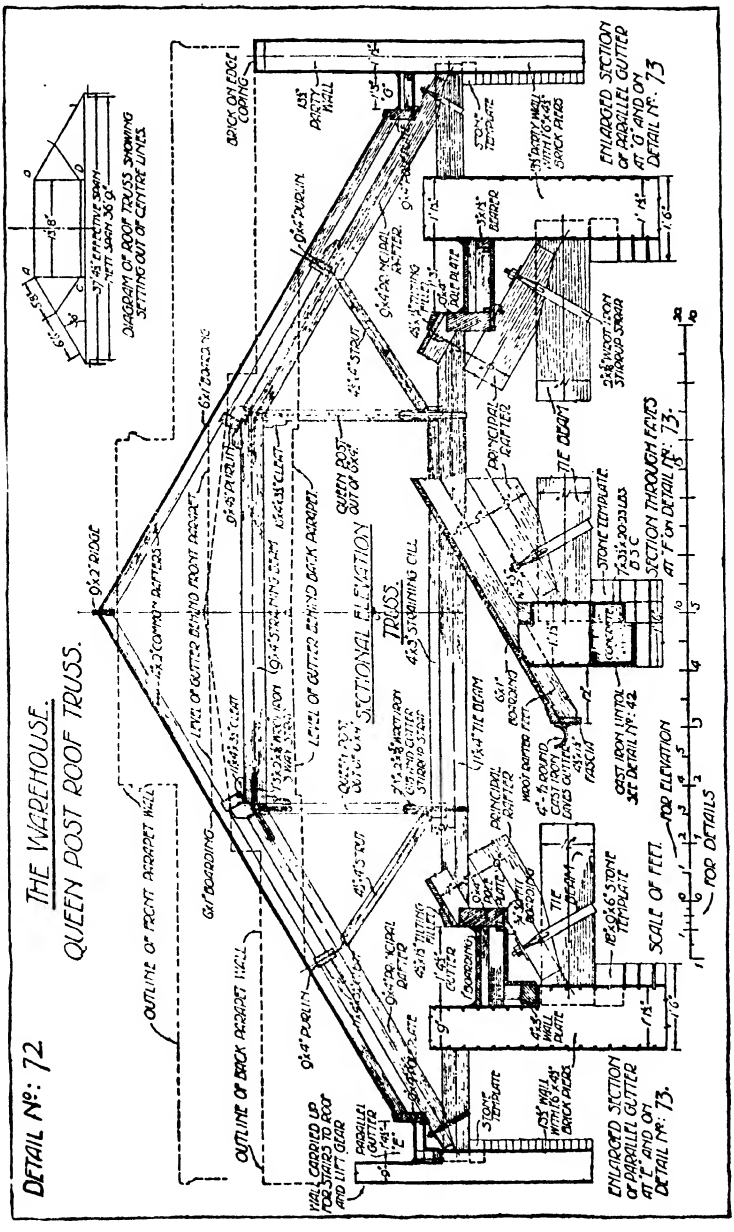
The general principles which govern the setting out of roof trusses have already been stated in Chapter Eight, but are reviewed here for application to wooden roofs. As the rafters increase in length they need additional support, which is provided by purlins. The spacing of the purlins is decided by the strength of the rafters; if 4″ × 2″ rafters are employed the unsupported length may not usually exceed 8 ft. especially if a heavy covering is used and the roof is exposed freely to the wind, hence the principal rafter should be subdivided to provide support at or near purlins, and the latter should not exceed 8 ft. centres in normal cases.

The unsupported length of a tie beam is generally accepted at a maximum of 15 ft., but this is only applicable to unceiled roofs; where ceilings are attached the maximum length without support should be reduced to from 10 to 12 ft.

250. Queen-post roof—spans from 30 to 42 ft. Concentrating attention on roof trusses suitable for the above spans, the only truss in general employment for timber construction is the queen-post truss. Its outline is shown in detail No. 72; it differs from the king-post in having two vertical tension members, called "queen-posts", which are strutted apart at their heads by a horizontal beam, named a "straining beam". The function of the latter is to receive the thrusts from the heads of the principal rafters. The thrusts from the two struts tend to force the queen-posts inward at their feet. This thrust must be resisted by the tenon on the foot of each post unless an additional member, called a "straining cill", is placed between them, as indicated in the line diagram.

A particular feature of this truss in its commonest form is the absence of the upper triangle in the main frame and the use of a rectangular centre bay in the frame. Both these peculiarities arise from the difficulties of jointing timber obliquely, furthered by a desire to make some use of the roof space, such as may be gained by placing a light floor upon the centre part of the tie beams.

251. Better form of queen-post truss. In the better forms of queen-post truss the principal rafters extend from eaves to ridge while a secondary rafter extends from the tie beam to the queen-post only; this gives a truss similar to the ordinary form described in the last paragraph, but with two additional principal rafters to complete the roof triangle. This variation of the form renders the trusses capable of resisting heavy wind pressure, of supporting ceiling and flooring loads, or other variable and possibly accidental loads. For these reasons it has been popular in exposed industrial areas in some parts of the north of England.


DETAIL No: 72
THE WAREHOUSE.
QUEEN POST ROOF TRUSS.
DIAGRAM OF ROOF TRUSS SHOWING SETTING OUT OF CENTRE LINES.
SECTIONAL ELEVATION OF TRUSS.
9"x2" RIDGE
OUTLINE OF FRONT PARAPET WALL
OUTLINE OF BACK PARAPET WALL
LEVEL OF GUTTER BEHIND FRONT PARAPET
LEVEL OF GUTTER BEHIND BACK PARAPET
BRICK ON EDGE COPING
ENLARGED SECTION OF PARALLEL GUTTER AT 'G' AND ON DETAIL No: 73
ENLARGED SECTION OF PARALLEL GUTTER AT 'E' AND ON DETAIL No: 73.
SECTION THROUGH EAVES AT 'F' ON DETAIL No: 73.
SCALE OF FEET.
FOR ELEVATION
FOR DETAILS

252. Defects of the queen-post truss. This form of truss has one great defect, viz. it is not economically adapted to resist irregular loading and wind pressure.

The rectangular portion is capable of distortion, owing to lack of triangulation, and distortion is only avoided by making at least two of the angular joints of the rectangle perfectly rigid; the junctions of rafters, queen-post and straining beam afford the best means of accomplishing this through the medium of metal plates or straps, as will be explained in a later paragraph. The continuous tie beam also assists in preventing distortion so long as its joints with the queen-posts remain close and rigid.

The improved form of truss maintains its outline by conversion into a large complete triangle with the continuous rafters, these being bolted through the shorter secondary rafters below the queen-post head to resist distortion.

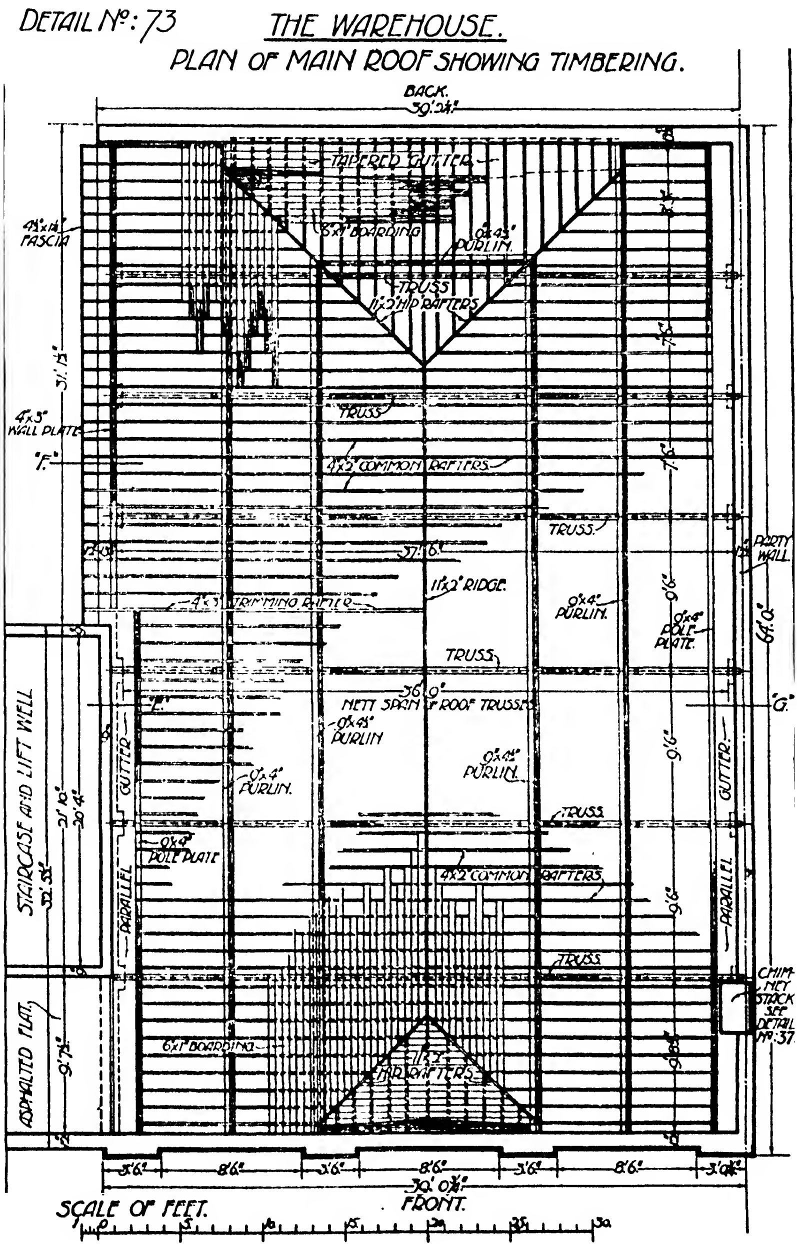
253. Roof of warehouse. Queen-post trusses are adopted for supporting the timbers of the warehouse roof. A complete plan of this roof is given in detail No. 73, and shows the span and the centre to centre spacing of the trusses.

The roof as a whole is plain, with the exception of two hipped ends, which are necessary to the scheme of design in order to avoid interference with the treatment of the front and back elevations. The front façade, being high enough at the parapet to hide a portion of the triangular roof section, requires only a short length of the front apex to be hipped, but the back elevation, having its parapet at a lower level, requires a greater length of the back apex to be removed. In each case the hipped ends have the same slope as the main roof section.

The position of the hips, together with the window spacing and the selection of practicable positions for the attached piers under the trusses, causes a somewhat irregular disposition of the latter to be adopted. Commencing at the front, the first bay measures 9′ 8½″ from the parapet wall to the centre of the truss, the next three bays are 9′ 6″ centres, the two following bays are 7′ 6″ centres and the last bay 8′ 3″ from centre to inside of parapet wall.

It will therefore be seen that the three back trusses will carry considerably less load than the rest—though not quite uniform in spacing and loading—and there might usefully be a difference in the thickness of the trusses. The lighter ones should be 4″ thick and the rest 5″ thick, elevation dimensions in the width of the members being similar for all the trusses.

The following details represent the construction of the more closely spaced trusses, which are 4″ thick.


DETAIL Nº: 73
THE WAREHOUSE.
PLAN OF MAIN ROOF SHOWING TIMBERING.
BACK.
39'·2½"
TAPERED GUTTER
4½"x1½" FASCIA
6"x1" BOARDING
9"x4½" PURLIN.
TRUSS
11"x2" HIP RAFTERS
TRUSS
4"x3" WALL PLATE
"F."
4"x2" COMMON RAFTERS
TRUSS.
PARTY WALL.
37'·6"
11"x2" RIDGE.
9"x4" PURLIN.
4"x3" TRIMMING RAFTER
9"x4" POLE PLATE.
64'·0"
TRUSS
36'·9"
NETT SPAN OF ROOF TRUSSES
"F."
"G."
9"x4½" PURLIN
9"x4½" PURLIN.
9"x4" PURLIN.
GUTTER
GUTTER
STAIRCASE AND LIFT WELL
9"x4" POLE PLATE
TRUSS
4"x2" COMMON RAFTERS
PARALLEL
PARALLEL
TRUSS
CHIMNEY STACK SEE DETAIL Nº:37.
ASPHALTED FLAT.
6"x1" BOARDING
11"x2" HIP RAFTERS
3'·6" 8'·6" 3'·6" 8'·6" 3'·6" 8'·6" 3'·0½"
39'·0½"
FRONT.
SCALE OF FEET.
0 5 10 15 20 25 30

254. Construction of queen-post trusses. Detail No. 72 shows the elevation of the complete truss. Market sized deal timber is available and utilised as follows:

Tie beam ...	11″ × 4″
Principal rafters	9″ × 4″
Queen-posts ...	$4\frac{1}{2}$″ × 4″ (out of 6″ × 4)
Straining beam	9″ × 4″
Struts	$4\frac{1}{2}$″ × 4″
Straining cill ...	4″ × 3″

In setting out the detail, the centre lines for each joint are made to intersect at a common point so far as possible. This is important when more than two members meet, or where two members intersect over a support. In the latter case the line of thrust at the bearing is generally assumed to pass through the centre of the template because the latter is the distributing medium to spread the load over sufficient walling to avoid crushing.

Some constructors object to the above method and attempt to make the thrust line, or reaction, occupy the centre of the wall. If a "through stone" template can be utilised this is very satisfactory for distributing the load, but otherwise it is faulty because (*a*) if the template is not the full width it is impossible to ensure that the courses of brickwork behind the template will transmit load equally with the thicker material of the template, and (*b*) the joint of the principal rafter will usually come too near the end of the tie beam requiring special care to be exercised in jointing and fixing to avoid failure by shear. The latter difficulty may be overcome by cutting the joint back and using a heel strap, as shown in Vol. I.

The joints in the truss should now be studied in detail, taking note of the nature of the force in each member and the provision to resist it.

255. Joints at foot of principal rafter and head of strut. Detail No. 74 shows these two joints. The rafter is in compression and the tie beam in tension, hence the joint at the rafter foot is formed to transmit the thrust from the rafter effectually to the tie beam and to permit the latter to resist it. For this purpose a deeply housed oblique bridle joint is satisfactory, the depth of the housing being usually limited to half the depth of the rafter or to one-third of the depth of the tie beam, whichever is the smaller.

The tenon is $1\frac{1}{4}$″ thick, approximately one-third the thickness of the rafter.

To keep the joint in position when lifting the truss and also to guard against failure by shearing off the material of the tie beam behind the shoulder of the joint, the rafter is held down by a foot

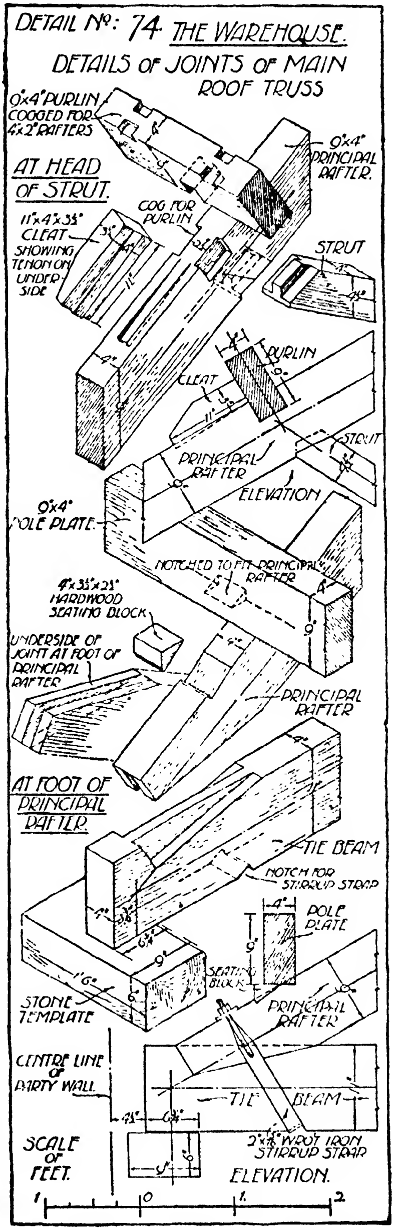
stirrup with two bolt ends and an adjustable back plate. The joint can be tightened at any time if the nuts are accessible.

The detail shows the end of the tie beam where it rests on the party wall; the bearing must be shortened to $6\frac{3}{4}''$ in order to keep the end of the beam $4\frac{1}{2}''$ from the centre line of the party wall. All other bearings may be 9″ long.

The joint at the head of the strut being in compression, an oblique joint to resist thrust must be employed here. It may be either a single abutment and tenon or a bridle joint. In either case the thrusting shoulder is made to bisect the angle between the two members, or placed in the vertical line through the angle, which will usually approximate to the bisection. This deviation from the right angled shoulder is wise because it prevents a slightly loose joint falling away during assembly and erection, before sufficient load comes upon the rafter to keep it close.

The cleat to give support to the back of the purlin is typical of the best construction; it may either be housed only, or tenoned, like the cleat on the side of the queen-post, and is independent of nails except to keep it in position until the load is transmitted to it.

256. Joint at head of principal rafter and queen-post. A large scale elevation of this joint is given in detail No. 75, along



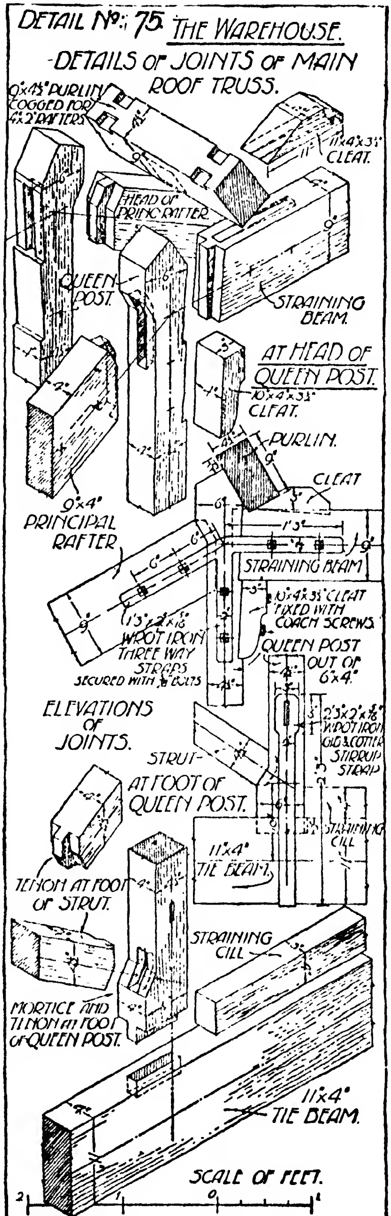
with isometric views of the dissociated members. In arranging the junction of the three pieces, viz. rafter, queen-post and straining beam, the centre line principle is adhered to, the centres intersecting at a common point.

In this case the rafter and straining beam are in compression and the queen-post in tension, hence the inclined rafter must be prevented from sliding up the side of the post and the latter from dragging downwards. To accomplish this the queen-post is made wider at the head than below the joint, being reduced at the centre by $1\frac{1}{2}''$ and formed so as to provide a seating at right angles to the inclination of the rafter.

The head of the rafter is tenoned to the post, the tenons being $1\frac{1}{4}''$ thick, and the mortices cut in square at the top to resist thrust and to avoid "undercutting" and also to prevent sharp angles on the tenons, which would be useless and wasteful of labour.

On the opposite side of the post the straining beam is tenoned to it and housed with a bevelled shoulder, which allows the under edge to have a bearing surface in addition to that provided by the tenon. In the best work a cleat is placed beneath the bearing end of the straining beam, and is bevel-housed to the post and spiked or coach screwed in position.

These provisions for good vertical support to the beam



are necessary because a purlin is placed immediately above the joint, bearing upon a bed block or cleat which is connected by a bevelled housing or by a long splayed tenon to the straining beam.

To facilitate the assembling and fixing of the joint and to make it rigid against wind pressure, as well as to allow the truss to be lifted bodily into position, wrought iron three way straps are fixed to each face of the joint. These straps are of $2'' \times \frac{5}{16}''$ metal with arms 15″ long and are secured by two $\frac{5}{8}''$ bolts to each arm at 6″ centres.

257. Joint at foot of queen-post. The same detail also shows the joints between queen-post and strut and between queen-post and tie beam. The strut bears against the square shoulder formed by reducing the width of the post, and the joint is a single abutment and tenon; because of the downward thrust transmitted by the strut a length of at least 4″ of material should be left on the widened base for resistance.

As in the case of the king-post—see Vol. I—it should be clear from the arrangement of the joint that no thrust is transmitted to the tie beam. The tenoned and strapped joint between beam and post is therefore arranged to keep the pieces in the correct position and to support the weight of the beam and of the proportionate load due to any ceiling or other weight suspended from the beam, which would be transmitted through the post to the rafters and hence to the support.

To draw the joint tight and maintain it in this position, while at the same time tightening the main joints of the frame, the shoulder of the post is cut about $\frac{3}{4}''$ short of the horizontal line of the tie; when pulled close by a draw bolt or wedged stirrup strap, the tie beam is cambered, thus pulling the ends inwards and thrusting the rafters upwards.

The amount of camber given depends upon the span and the initial straightness of the timbers employed. In any case it should not be excessive because the camber is equivalent to deflection of a beam under load, the load being the force exerted by the bolt or wedges, and considerable stresses may be caused by the forced bending.

The straining cill between the queen-posts is laid edgewise upon the tie beam and is intended to resist the side thrust on the posts caused by the struts. It should fit tightly between them.

258. Roof purlins, ridge and pole plate. The purlins and ridge are placed in continuous lines across the several bays, as shown in detail No. 73, and may have the joints in their length arranged over alternate trusses throughout the roof; the length will usually be

selected to span two bays. For longitudinal jointing of the purlins one of the forms of scarfed joint illustrated in Vol. I, may be employed.

The position and mode of support of the upper purlin should be noted; it rests upon a bevelled bed block or cleat (see paragraph 255) and upon the splayed head of the queen-post which is continued above the rafter and straining beam as far as possible to resist the thrust from the rafter. Advantage is therefore taken to utilise it for a purlin support, a most convenient position, especially in some forms of hipped roof.

A pole plate is shown at the foot of the rafter in detail No. 72. Its purpose has been explained in Vol. I and attention drawn to the fact that it transmits its load directly to the truss. The plate rests upon a small triangular block of hardwood, which is housed obliquely to the back of the rafter; it forms a bearing and resists the thrust caused by the load in a direction parallel to the rafter.

Pole plates are usually required to form the sides of parallel parapet gutters and must therefore be vertical.

The section shown in the example is taken through the roof plan at E.

259. Projecting eaves to warehouse roof. A small portion of the warehouse roof, where the external wall abuts on the loading shed, is constructed with an overhanging eaves, having a clear projection of 12″ to the outside of the fascia. Detail No. 72 also shows a vertical section taken through one of the window openings overlooking the loading shed at the point F on the plan, and indicates the side wall, 4½″ attached pier, bearing template for roof truss and also the rafters, eaves gutter and supports. Included also in the detail is the method of supporting the walling over the window opening by a concrete and iron lintol; see also detail No. 42.

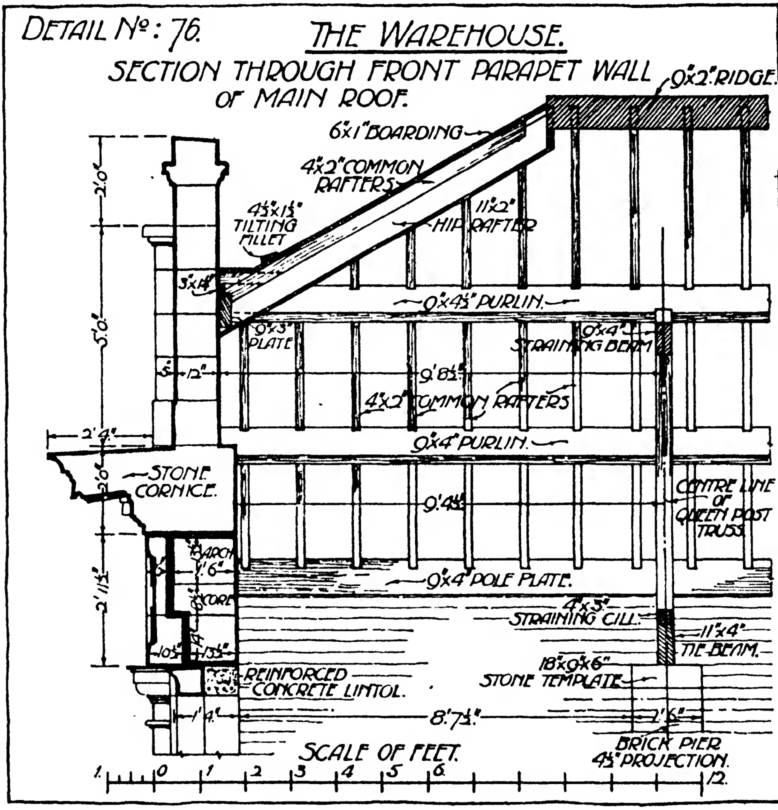
260. Hipped end and gutter behind front parapet of warehouse. Detail No. 76 is a vertical section through the front parapet of the warehouse.

In this detail is shown the relationship of the roof to the cornice and parapet, and the position of the gutter across the hipped end of the roof. The distance from the front wall to the centre line of the truss is 9′ 4½″. The pole plate and two purlins rest upon the truss and continue to the front wall. The slope of the hipped end lies entirely above these horizontal members, and springs from a 9″ × 3″ plate running parallel to the front parapet and framed to the upper purlins.

Two 11″ × 2″ hip rafters are supported on the 9″ × 3″ plate and converge to meet the 9″ × 2″ ridge to which they are fixed. One of

the hip rafters is visible in the section, along with the 4″ × 2″ common rafters which are splayed against the hip and set in the same plane as its top edge.

A reference to detail No. 73 will assist in making clear the position of the hips and jack rafters and the mode of supporting the main timbers of the roof.

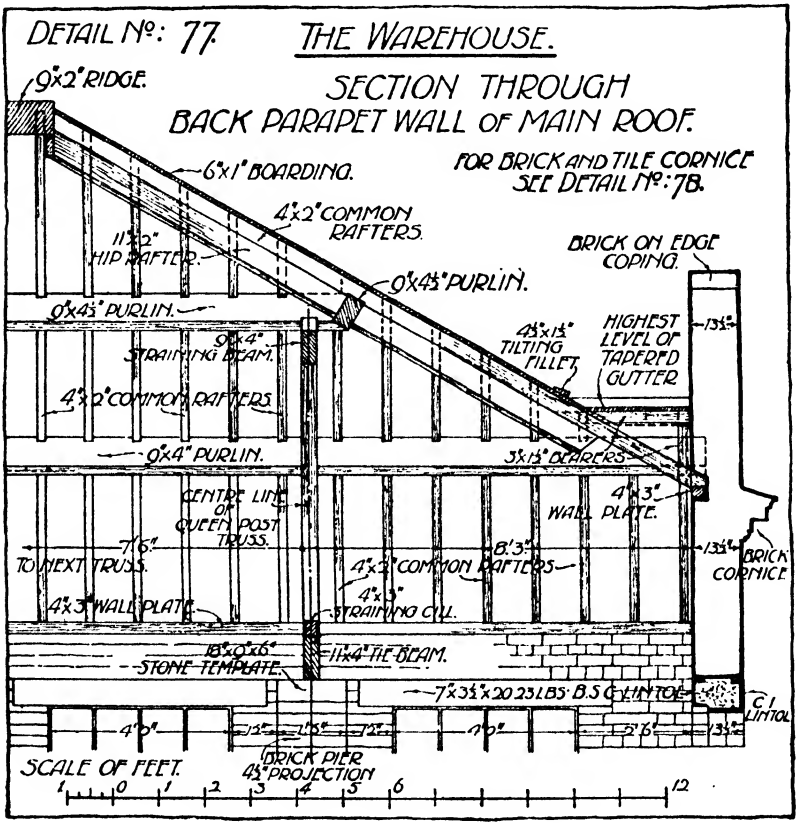


To obtain the bevels for the cuts of hip and valley rafters, and of jack rafters in the roofs of our studies, is scarcely within the scope of this volume, hence students of carpentry are referred to special works thereon or to text-books on geometry of building construction.

261. Hipped end and gutter to back of warehouse roof. The construction of the hipped end to the back of the warehouse is illustrated in details Nos. 73 and 77. In this case the hipped surface is much larger and the sectional elevation of detail No. 77 shows the

treatment for a slope rising from above the first purlin level, to the ridge.

The truss nearest to the back wall rests upon the pier between two windows and the hips pass over the truss before rising to the level of the ridge. Referring to the roof plan it will be seen that the hip rafter springs from the surfaces of the 9″ × 4″ purlin, to which the



rafter is splay notched and spiked, while a similar joint is formed at the head against the ridge, the latter passing forward far enough to receive the full breadth of the hips in plan—detail No. 73—and thus allow for bolting through the sides to clasp the ridge securely.

Where the hip rafters stand below the ridge sufficiently, they should be notched to receive the latter—otherwise they are usually splayed in one vertical cut, then spiked in position from both sides.

262. Purlins at return end. The main upper purlin, which is $9'' \times 4\frac{1}{2}''$ in cross section to suit its position against the queen-post, passes over the first truss, rests solidly upon its cleated support and splays against the side of the hip rafter. The return purlin, across the hipped end, is similarly jointed between the hips.

In cases where the return purlins become too long to carry their load without using an abnormal size of beam, it may become necessary to use two half trusses secured against the queen-posts of the first truss and resting on the end wall. This necessity occurs in full hipped ends for spans of 25 ft. and upwards, hence in king-post roofs the provision would be made by one half truss in the middle of the span secured to the king-post in a similar manner to that described above.

263. Lead-lined gutters. Tapering parapet gutter. Parallel lead-lined gutters have already been dealt with in Vol. I, but another example occurs in this roof along the party wall eaves, and also on the opposite side over a portion of the length. The student should carefully peruse details Nos. 72 and 73 for the purpose of noting slight differences in the application.

Tapering gutters are in common use behind parapet and other vertical walls; they are formed by constructing a platform in suitable steps and with the necessary fall, over the bearing of the common rafters.

264. Tapering parapet gutters to warehouse roof. Two cases of this kind occur in the warehouse roof and are shown in section with isometric details at Nos. 76, 77 and 78.

Referring back to detail No. 73 it will be seen that the foot of the hipped surface here is only about 14 ft. long and a gutter is required to discharge the water to the roof slopes on each side. This is economically done by two falls. viz. from the centre to each side, and consequently a narrow gutter will serve. The gutter averages 9″ wide and is formed by $3'' \times 1\frac{1}{2}''$ bearers nailed horizontally to the side of the common rafters, and bearing at the wall ends upon a $3'' \times 1\frac{1}{4}''$ packing placed on the $9'' \times 3''$ plate.

A fall of $1\frac{1}{2}''$ to 2″ is desirable for each half of the gutter, hence the bearers must vary in level accordingly; they are notched down at the packing piece as required for adjusting the fall.

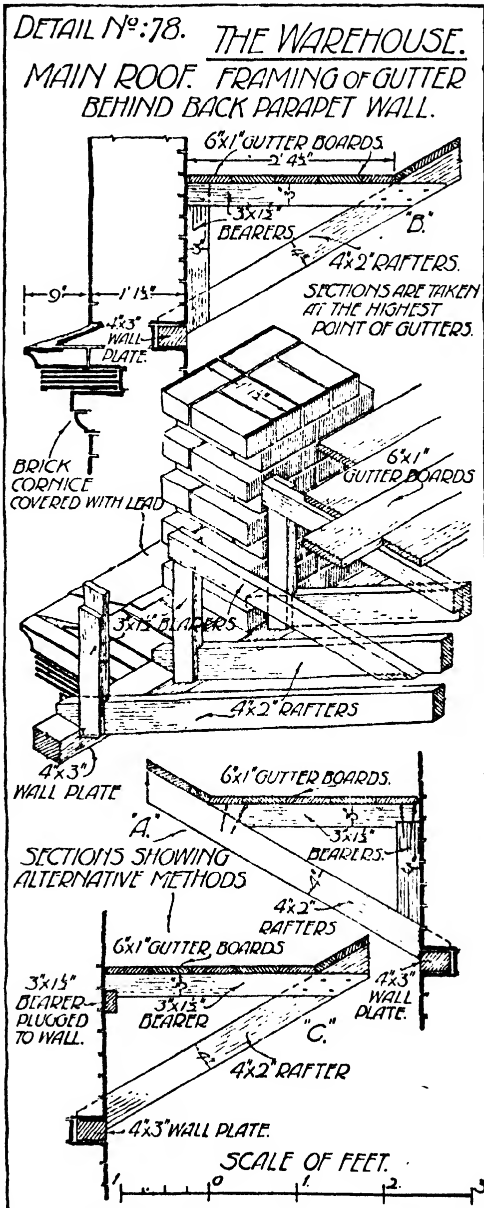
The roof boarding is continued to the edge of the gutter and the two sets of boards mitred at the junction. To lift the eaves of the slates clear of the gutter and at the same time to facilitate their bedding, a $4\frac{1}{2}'' \times 1\frac{1}{2}''$ wood tilting fillet is placed 3″ up the slope and parallel with the intersection of the gutter and roof boarding. This fillet is covered with lead when lining the gutter.

It should be noted that the fall of the gutter causes the latter to become narrower in the direction of the flow, so that the gutter is tapered between the parapet and the eaves of the slating.

265. Wide tapering gutters. The roof plan shows a similar tapering gutter, but much wider in plan, behind the back parapet wall. The normal width of such gutters is about 12″, but in this case the level has been raised in order to clear the purlins; hence the mode of support is varied from the previous detail to suit the conditions.

In the sections of detail No. 72 the higher and lower levels of the gutter are shown in dotted lines, the lead covering being laid in two lengths on each side of the centre. The full length of the gutter is 24 ft. and necessitates a drip about midway on each side.

The gutter bearers are framed triangular brackets, out of $3'' \times 1\frac{1}{2}''$ material and three forms of jointing are shown in detail No. 78. The one marked A gives a firmer seating and is



not so dependent upon nailing, being splayed upon the rafter back and nailed in position. At B the bracket is seen to be nailed on the side of the rafter and is thus easier of adjustment though not so solid; the right angled connection to the vertical bearer is halved and screwed and the bracket as a whole is then adjusted to the fall, marked, cut and nailed in position. A third method is shown at C, where the gutter bearers are nailed to the sides of the rafters and supported at the wall end upon a $3'' \times 1\frac{1}{2}''$ bearer plugged to the wall.

To adjust the levels the bearer may be laid to the required fall, or it may be kept level and the gutter bearers notched upon it at varying depths.

Flat Roof over Staircase and Lift Enclosure

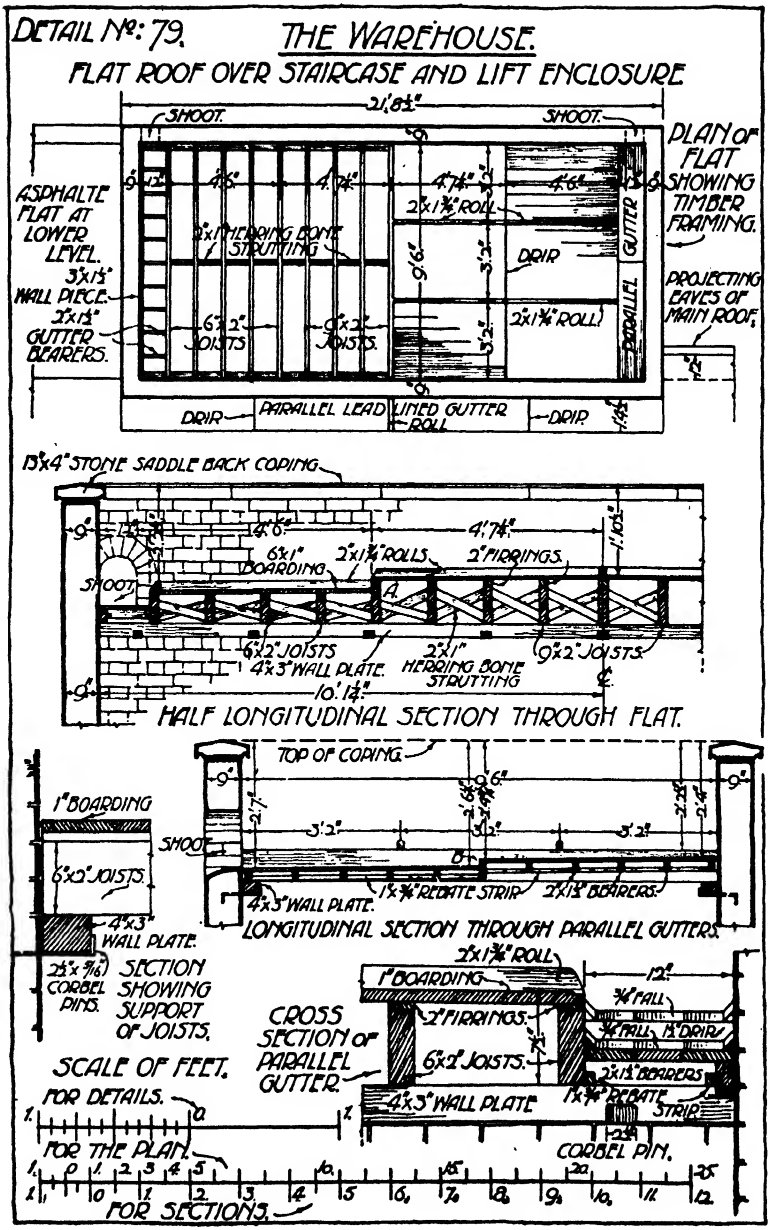
266. General arrangement of flat. When a flat roof is to be covered with lead a timber framework, suitably boarded, is first required on which the lead sheets may be laid and jointed; the pieces employed in the lead covering should not exceed such as may be cut from the width of the roll nor too large for convenient handling.

Sufficient fall must be provided for ensuring a rapid discharge of rain water, and arrangements made for its collection at one or more suitable points, and in addition the framework should be economically disposed to obtain a rigid platform on which the lead may be bossed into shape at joints and angles.

The boarded covering should have its grain in the direction of the flow, with the necessary drips dividing it into sections for the convenient jointing of the lead sheets at right angles to the floor. For longitudinal jointing the edges of the sheets are lapped over wood rolls or formed into hollow rolls as illustrated and described in Vol. I.

267. Flat over warehouse stair. As an example of the construction for a lead flat of moderate size that portion of the warehouse roof has been selected which covers the staircase and lift enclosure and rises to a higher level than the eaves of the main roof.

The staircase is enclosed by 9″ walls at the higher level and these are carried upward to form a parapet, rising $1'\ 10\frac{1}{2}''$ above the highest point of the flat-boarding to the top of the stone coping; within these walls the space to be roofed is $20'\ 2\frac{1}{2}'' \times 9'\ 6''$. The space is bridged by 2″ joists across the short span and the flat is divided into symmetrical portions, falling away from the centre to the ends longitudinally and terminating at the end walls in gutters which discharge through shoots into down pipe heads at the external wall.


DETAIL No: 79.
THE WAREHOUSE.
FLAT ROOF OVER STAIRCASE AND LIFT ENCLOSURE
PLAN OF FLAT SHOWING TIMBER FRAMING.
ASPHALTE FLAT AT LOWER LEVEL.
3"x1½" WALL PIECE.
2"x1½" GUTTER BEARERS.
SHOOT
2"x1" HERRING BONE STRUTTING
6"x2" JOISTS
9"x2" JOISTS.
2"x1¾" ROLL
DRIP
GUTTER
PARALLEL
PROJECTING EAVES OF MAIN ROOF.
DRIP
PARALLEL LEAD LINED GUTTER
ROLL
13"x4" STONE SADDLE BACK COPING
6"x1" BOARDING
2"x1¾" ROLLS.
2" FIRRINGS.
6"x2" JOISTS
4"x3" WALL PLATE.
2"x1" HERRING BONE STRUTTING
9"x2" JOISTS
HALF LONGITUDINAL SECTION THROUGH FLAT.
TOP OF COPING
1" BOARDING
6"x2" JOISTS.
4"x3" WALL PLATE.
2½"x 9/16" CORBEL PINS.
SECTION SHOWING SUPPORT OF JOISTS.
1"x¾" REBATE STRIP
2"x1½" BEARERS.
LONGITUDINAL SECTION THROUGH PARALLEL GUTTERS.
2"x1¾" ROLL
1" BOARDING
2" FIRRINGS.
6"x2" JOISTS.
¾" FALL
1½" DRIP
2"x1½" BEARERS
4"x3" WALL PLATE
1"x¾" REBATE STRIP
CORBEL PIN.
CROSS SECTION OF PARALLEL GUTTER.
SCALE OF FEET.
FOR DETAILS.
FOR THE PLAN.
FOR SECTIONS.

268. Timber framing and boarding to flat. The joists are supported by a pair of 4″ × 3″ level wall plates against the longer sides of the opening, the plates being in turn carried by wrought iron corbel pins, $2\frac{1}{2}''\times\frac{5}{16}''$, built into the wall at intervals of 2′ 3″ to 2′ 6″, as shown in detail No. 79.

To obtain the fall of the flat, and to provide for the formation of a drip at the centre of each half of the flat, the higher platform is supported upon 9″ × 2″ joists and the lower one upon 6″ × 2″ joists, while the fall is obtained by packings or "firrings" which vary in thickness to suit the slope and are fixed between the joists and the boarding.

Where a drip occurs the lower boarding is first laid and a second packing placed over the head of the boards, thus forming the drip and bringing the height to that required for the upper platform, as shown at A in the longitudinal section.

When the span of the joists exceeds 6 ft. a row of herring-bone strutting should be inserted at the centre of the span, or solid strutting may be substituted if the joists are shallower than 6″.

269. Parallel gutters to ends of flat. The end gutters are formed by laying a $3''\times 1\frac{1}{2}''$ wall plate on edge, to rest upon the 4″ × 3″ plates at each end, and providing intermediate support by nailing it to wood plugs in the end wall; $1''\times\frac{3}{4}''$ rebate strips are then nailed to the required fall on the inside of the $3''\times 1\frac{1}{2}''$ plate and the first 6″ × 2″ joist. Gutter bearers, $2''\times 1\frac{1}{2}''$, are notched transversely across these rebate strips, a drip formed at the centre of the length and boards laid lengthwise of the gutter in two lengths and packed up at the drip as shown at B. An enlarged section of the gutter is shown at the foot of the detail, and illustrates the use of bevelled angle strips at the base of the gutter to remove the sharp angles. The detail shows a plan of the flat, with the timber framing on the left hand half and the boards laid in position on the right hand half. The drips, rolls and gutter are clearly shown in the latter portion of the drawing and also in the longitudinal sections through flat and gutter.

For the leadwork to this flat see paragraph 343.

CHAPTER TWELVE

PARTITIONS

Timber Partitions

While it is not recommended that a study of framed timber partitions be made in an average building construction class—owing to the introduction of other forms of partition which have largely displaced timber—it is felt that at least one illustration of vertical timber framing, designed to carry load, should be included in a treatise on building construction; for the reasons—amongst others—given in the next paragraph.

270. The study of timber partitions in Vol. I included brick-nogged, common, quarter or stud, and trussed partitions, in all of which timber was employed to form the framework of the partition and the surface finish was obtained by applying lime plaster upon the brick filling, or upon laths nailed to the studs and framing.

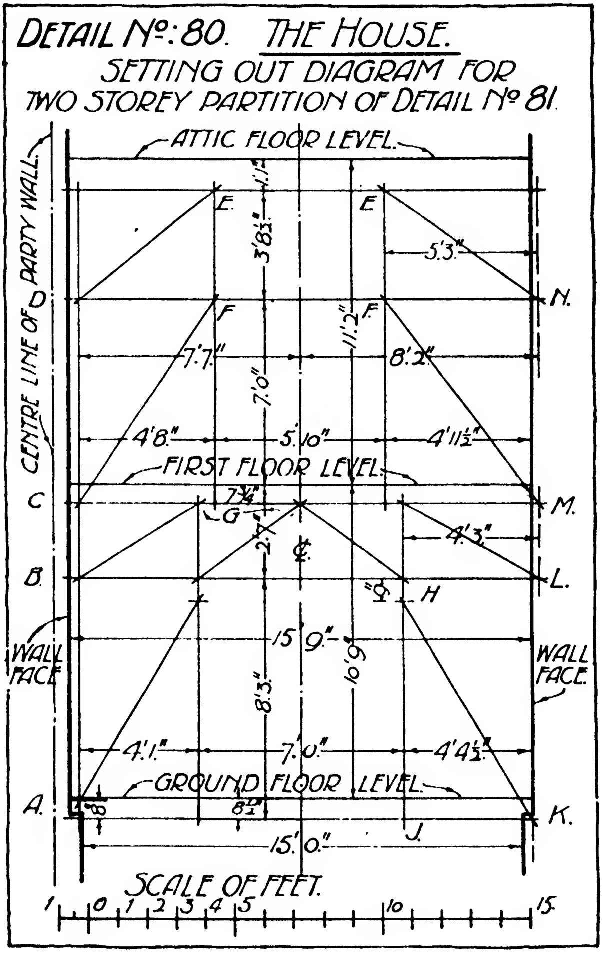
While timber partitions of large size are not now in common use owing to the developments in employing fire-resisting material for this purpose, one example of timber trussing is included in the form of a two storey partition *to illustrate the principles of timber jointing as applied to trussed carpentry work of all kinds*. It must also be recognised that in some parts of the world, particularly in America, and our colonies, where timber is plentiful and artificial building materials are scarce, it is still a common practice to adopt such timber construction not only for partitions but for whole buildings, though the type of construction employed is often of a more temporary character.

In addition, there is a considerable revival of timber construction in this country, and the principles here illustrated may be modified and adapted to many kinds of timber construction.

271. Trussed partitions. These were defined in Vol. I as triangulated frames, which may be so treated as to support their own weight or the weight of floors and ceilings. The principle of arranging the trusses is to dispose of the framing so that, by utilising struts and braces assisted by wrought iron tension bolts, the load may be transmitted to the bearings of the cill and head, without deformation of the partition as a whole and without causing undue deflection of its horizontal members.

In details Nos. 80 and 81 the principle is applied to a trussed partition two storeys in height.

272. Two storey trussed partition in house. In the construction of the house a trussed timber partition has been adopted which commences at the ground floor level and extends in one frame to



the attic floor level; it divides the dining and drawing rooms on the ground floor and the two large bedrooms on the first floor.

The frame is arranged with the following purposes in view:

(*a*) To carry its own weight and transmit this to isolated bearings.

(*b*) To prevent distortion by the settlement of surrounding brickwork.

(*c*) To support the bedroom and attic floor joists.

(*d*) To support the stud partition which divides the attic rooms immediately above.

The ground floor joists run parallel to the partition and do not receive any support therefrom.

The whole structure may be looked upon as consisting of two partitions, conveniently compounded, each passing through one storey, but with the head of the lower partition made to serve as the cill of the upper one. When the vertical members are secured above and below this central member, the two partitions are caused to act as one continuous frame.

The number and disposition of the members depend upon the conditions to be met.

It is required to provide a large doorway in the centre of the ground floor storey for communication between the dining and drawing rooms and to convert these rooms virtually into one large room for special occasions. No opening of any kind is required in the upper storey.

273. Form of truss for ground floor storey. The most convenient and economical form of truss for these conditions is shown in single outline at detail No. 80, where the centre lines of the main members are given. The principal dimensions are associated with the centre line setting out of the truss.

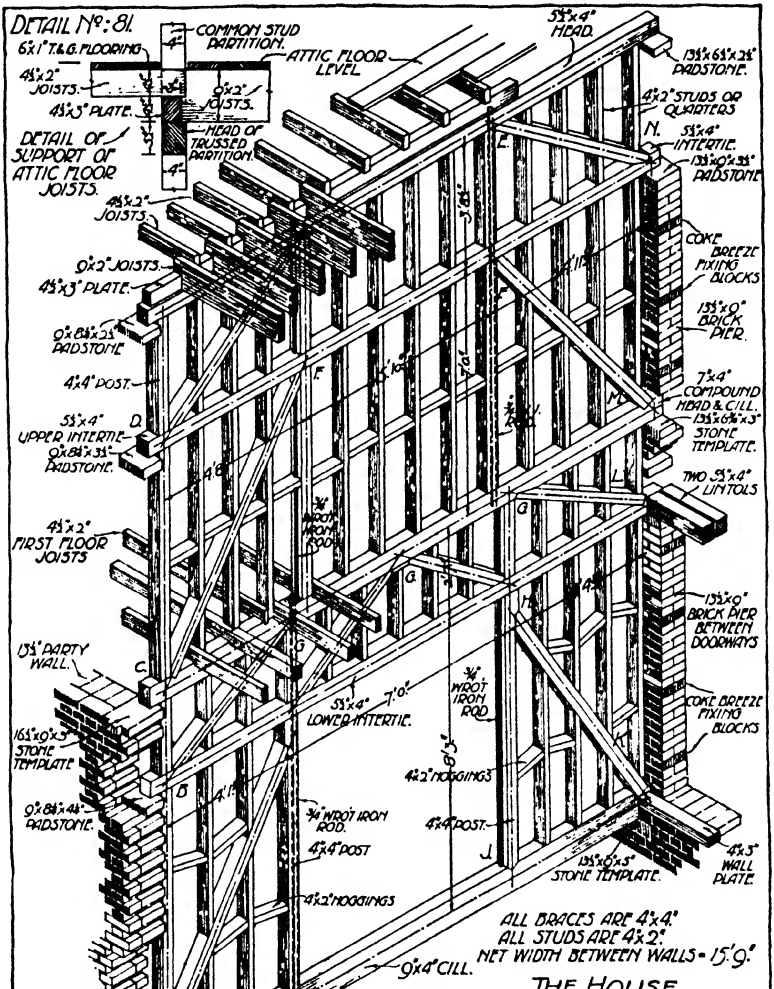
Consider the ground floor storey outlined by the rectangle ACMK. It stands between two walls 15′ 9″ apart and the height between ground and first floor levels is 10′ 9″. The opening for the doorway is required to be 7′ 8″ × 6′ 8″ measured in the clear.

274. Object of the truss. As the object of trussing this frame is to discharge the load upon the walls with the least distortion of the frame, it is triangulated by employing inclined struts across the rectangular divisions, with the struts sloping downwards towards the supports. This ensures compression, because the rectangles, under load, tend to droop at the side nearest the centre, which would cause the rectangles to become rhomboids if allowed to develop; the diagonals in the direction of the inclined members would tend to become shorter, and they are compressed in the process.

All diagonal members in timber partitions should be *struts* as far as practicable, because special and expensive fastenings are required for tension joints.

The term "brace" is commonly employed for all diagonals of timber partitions and also for similar diagonals in all kinds of trusses.

The example in detail No. 81 varies from previous ones, in having



THE HOUSE.

TWO STOREY TRUSSED PARTITION TO SUPPORT JOISTS OF ATTIC AND FIRST FLOORS.

three horizontal members to each storey. The intermediate member is termed an "intertie" and is usually employed in partitions 10 ft. or more in height.

Its object is (*a*) to transfer some of the load to other bearings and thus relieve the bearings at the cill and head, (*b*) to shorten the struts, which would be of excessive length if an attempt were made to brace the full height of the partition, and would lack stiffness to resist buckling if made from ordinary scantlings, (*c*) to form a separate trussed girder in the upper half of a partition, which is capable of transmitting the load above it to the supports when a large opening interferes with the bracing of the lower part, (*d*) to provide a separate girder from which the door posts and tension rods may be suspended when the conditions will not admit of a continuous lower cill.

The dimensions of the horizontal members for the ground storey portion of the partition are cill, 9″ × 4″; intertie, 5½″ × 4″; head, 7″ × 4″.

275. Door posts and intermediate posts. Door posts, or strong studs, are necessary at the sides of openings for the purpose of securing linings to which the doors may be hung.

These posts, due to their position, would become tension members if secured at their ends, and would support load upon the cill as well as resisting thrust from the inclined struts. One method of treating them is to use stirrup straps or draw bolts at the head and foot, and where continued to form an intermediate post in the upper portion of the truss, to connect the upper and lower posts by long flat straps across the intertie. This method is clumsy and not very efficient, as it does not provide for tightening the joints at the intertie.

276. Use of tension rods. A better method is to employ a light wrought iron bolt, passing through the full height of the storey, fitted with a nut and washer at each end. The posts are often omitted in this case and the struts framed into the intertie, but such work is frequently overstrained when assembled, by over-tightening the screws and distorting the intertie, head and cill, by the pull of the bolt and the thrust of the struts.

The best method is to use a door post and intermediate post in the same line, set out posts and struts to accurate lengths and employ the bolt for bringing all the joints close and to act as a tension member.

277. Placing of struts. There are opportunities to vary the method of placing struts in partitions and similar structures, the variation depending upon (*a*) the use of tension bolts or the alternative of posts

and straps, (*b*) the acceptance or otherwise of the centre line principle of setting out, and (*c*) personal initiative or preference in selecting the form of joint.

Before tension bolts became general, struts were most commonly jointed by providing an abutment on the posts between which they occurred as at A and H in detail No. 81. This secured a direct thrust at the abutment and also shortened the strut, but is a wasteful method in the labour of forming the joint; it also guarded against slack joints due to shrinkage of the horizontal timbers.

At all other parts of the partition the more modern method of placing has been shown, where all members are of minimum width, kept parallel with their centre lines intersecting at a common point.

In order to brace the upper central rectangle of the ground floor partition, two struts are employed, abutting on a short compression piece at C, and thus shortening the unsupported length of the head of the partition upon which the bedroom floor joists are supported.

Assuming that fairly well seasoned timber is employed and that the joints are well made and close on erection, very little slackening of the struts will occur due to placing them in the angles of the frame; the whole can be tightened and any seasoning defects largely remedied by screwing up all the nuts again when the building has been roofed and the work so far progressed that the framing is about to be covered.

278. Wall posts. Wall posts (as shown on the left of the detail) are sometimes employed for jointing struts upon, where the latter would run very close to the end of the beam at a bearing, if continued to meet it in the ordinary way as shown to the right.

It will also be seen that the intertie is liable to get the greater share of load upon its bearing due to the continuity of the trussed girder formed above it by the head and struts and the floor load it is called upon to carry. If a wall post is employed much of this load is transmitted to the cill provided the joints are tight and thus a greater uniformity of distribution is assured as is necessary for large spans and heavy loading.

In the example under consideration the latter point is of some importance, because the bearings on the party wall have to be increased by corbelling, in order to prevent the main timbers passing nearer than $4\frac{1}{2}''$ to the centre line of the party wall, as required by most bye-laws.

Wall posts are sometimes adopted to prevent the intermediate horizontal members being wedged off their bearings by driving studs in too tight, a common practical occurrence which may result in all the load being transmitted to one support. In this case either straps

or the preferable bolt must be employed, to obtain tight joints in the first instance; the bearings should also be packed so that the upper ones are slightly tighter than the lower, to allow for settlement of the brickwork when the full load comes upon the partition.

279. Bearings for horizontal members. At each bearing a stone template or padstone is employed and the lengths of the bearings vary from 4½″ to 6¾″. The latter length enables the ends of the horizontal members at the hall and staircase end of the partition to be covered with 2¼″ of brick, while the party wall bye-law is met by using bearings 4½″ long, except at the ground floor level, where 6¾″ is available.

At the party wall the stone templates are made large enough to pass through the wall and project to form corbels. The bearing templates should be carefully levelled and the timbers accurately seated thereon, and packed with slate if necessary.

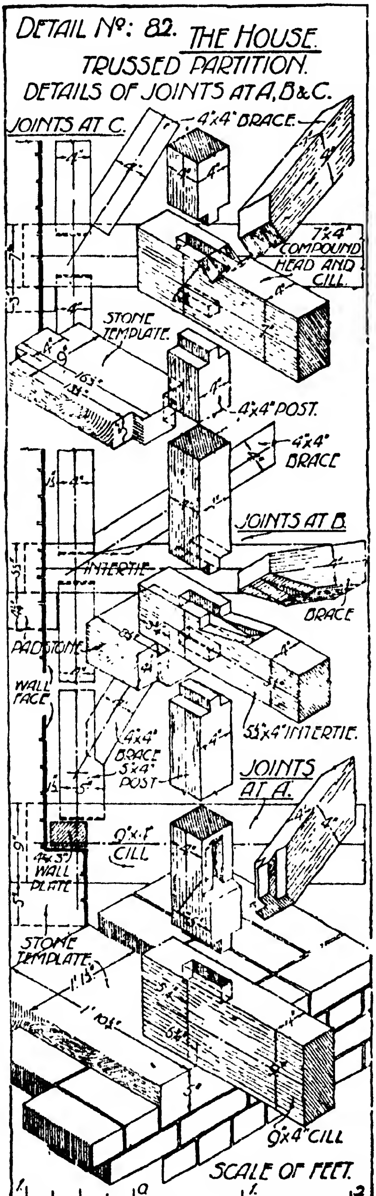
280. First floor storey of partition. The upper storey of the partition is erected upon the lower one by using the head of the latter for the cill of the new portion.

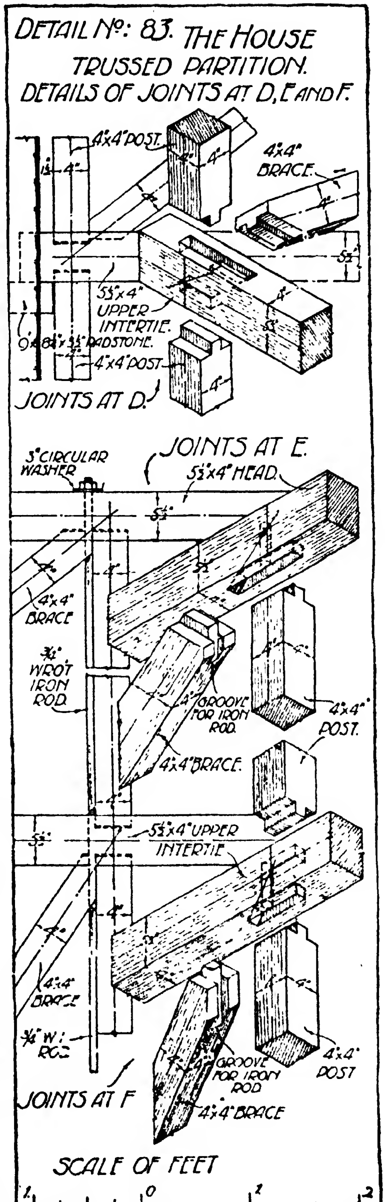
In this case there is no doorway to provide and the conditions allow of an almost duplicate arrangement of the ground floor storey, except that the middle posts are brought closer together to divide the unsupported length of head beam into three practically equal parts and at the same time allow the tension bolts to pass inside those of the lower storey. The bolts are placed on the opposite side of the posts in this case to bring them approximately into one vertical line; there is no obstruction to prevent this position such as exists in the reduced door post of the lower storey. Struts are easily notched over the bolts at their joints as shown in the details.

An intertie is again introduced for the purpose of shortening the struts, increasing the bearing surfaces for support, and generally to stiffen the structure.

There is no need to brace the centre bays of the upper partition because the length of unsupported head is not excessive and the loading is uniform. Where considerable variation of loads may occur from any cause the upper tier should be braced right across, and in this case cross-bracing would be suitable for such conditions.

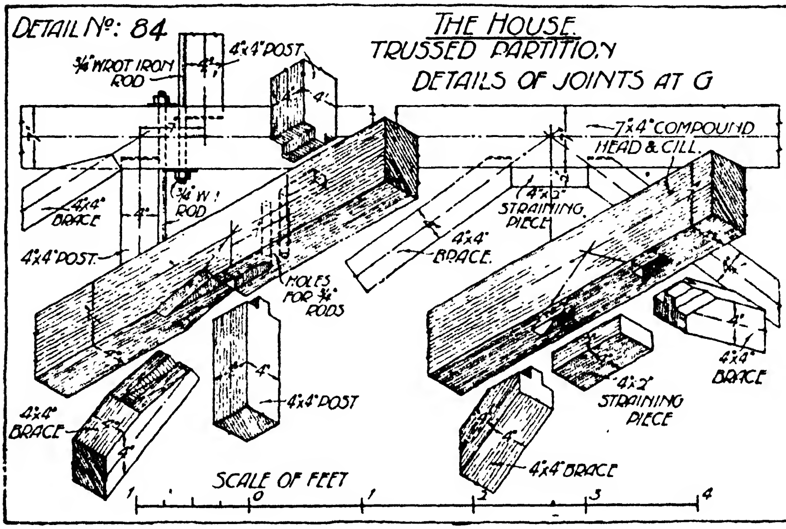
281. Joints in trussed partitions at braces and posts. Owing to the difference in size of the rectangles to be braced, which causes variation of slope in the braces of the partition, it has been found expedient to illustrate several forms of joint suitable for brace connections with posts and beams, embodied in the one structure. It is *not* intended that they should all be applied in a practical structure of a similar type, but that *a selection for repeated application should be made,* according to the form and conditions of the case.


DETAIL Nº: 82. THE HOUSE.
TRUSSED PARTITION.
DETAILS OF JOINTS AT A, B & C.
JOINTS AT C.
4"x4" BRACE
7"x4" COMPOUND HEAD AND CILL
STONE TEMPLATE
4"x4" POST.
4"x4" BRACE
JOINTS AT B
INTERTIE
BRACE
PADSTONE
WALL FACE
5½"x4" INTERTIE.
4"x4" BRACE
5"x4" POST
JOINTS AT A.
9"x4" CILL
4"x3" WALL PLATE
STONE TEMPLATE
9"x4" CILL
SCALE OF FEET.
1 0 1 2


DETAIL Nº: 83. THE HOUSE
TRUSSED PARTITION.
DETAILS OF JOINTS AT D, E AND F.
4"x4" POST.
4"x4" BRACE.
5½"x4" UPPER INTERTIE.
PADSTONE.
4"x4" POST
JOINTS AT D.
5" CIRCULAR WASHER
JOINTS AT E.
5½"x4" HEAD.
4"x4" BRACE
¾" WROT IRON ROD
GROOVE FOR IRON ROD
4"x4" POST.
4"x4" BRACE.
5½"x4" UPPER INTERTIE
4"x4" BRACE
¾" W.I. ROD
GROOVE FOR IRON ROD
4"x4" POST
JOINTS AT F
4"x4" BRACE
SCALE OF FEET
1 0 1 2

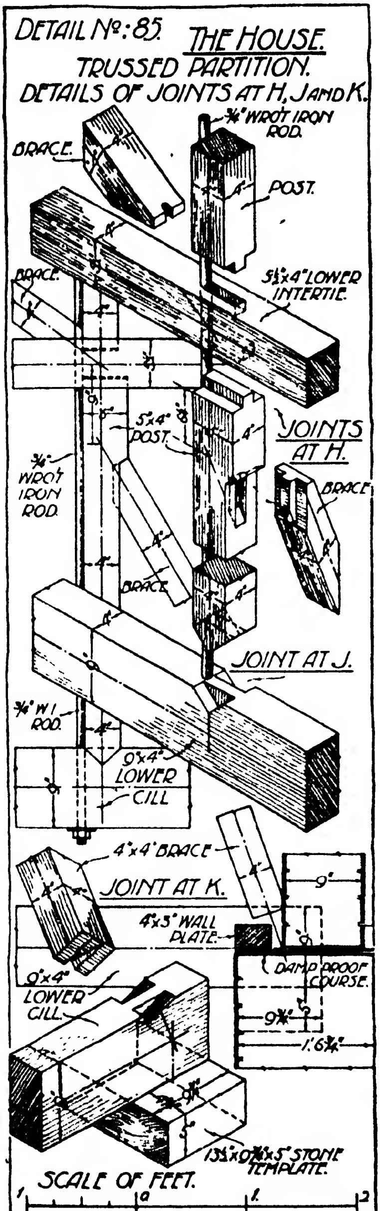
Details Nos. 82 to 86 illustrate some of the practicable forms of joint and their positions are referred to in the outline diagram, detail No. 80.

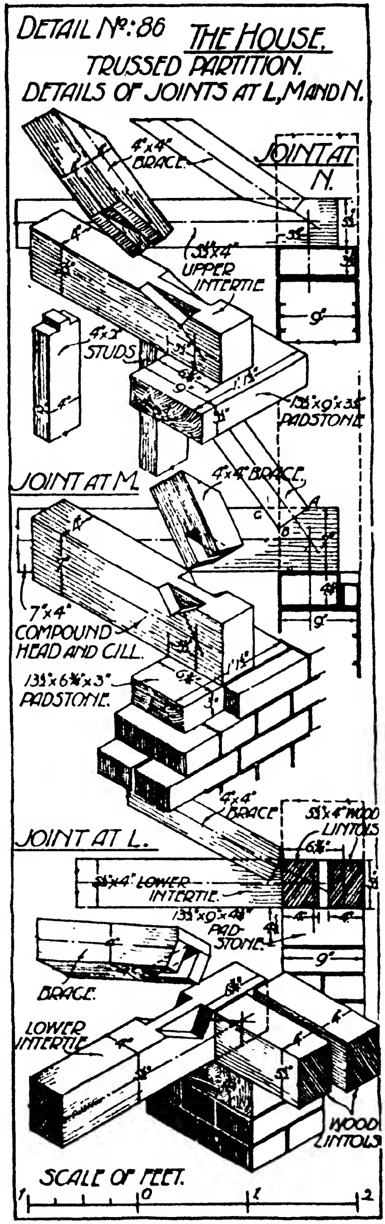
Detail No. 82 includes two groups of joints between the three members at A, the four members at B, and the four members at C. The assemblage at A shows a common mortice and tenon between the wall post and cill, and an oblique mortice and tenon with a square abutment connecting the wall post and strut; the tenons are 1¼″ thick and 1½″ to 2″ long.



The group at B illustrates the joints between the two sections of the wall post, the intertie and the upper brace. The intertie bears 2¼″ upon the solid wall, but the template projects 1½″ forward towards the wall post and thus provides a bearing of 3¾″. In this case the small inclination of the brace to the intertie causes considerable horizontal thrust, which can be effectively met by housing the joint at the cill so that part of the vertical shoulder abuts on the end grain of the intertie instead of bearing only upon the side of the wall post.

This treatment should be compared with the more usual one shown in detail No. 83 at D, where four similar members and their connections are detailed for the upper storey of the partition. The strut in this latter case has a greater inclination to the horizontal and produces a less thrust along the beam, and housing is therefore dispensed with.


DETAIL No: 85.
THE HOUSE.
TRUSSED PARTITION.
DETAILS OF JOINTS AT H, J AND K.
3/4" WROT IRON ROD.
BRACE.
POST.
BRACE.
5½"x4" LOWER INTERTIE.
5"x4" POST.
3/4" WROT IRON ROD.
JOINTS AT H.
BRACE
BRACE
JOINT AT J.
3/4" W I ROD.
9"x4" LOWER CILL
4"x4" BRACE
JOINT AT K.
4"x3" WALL PLATE.
DAMP PROOF COURSE.
9"x4" LOWER CILL.
1'6¾"
13½"x9¾"x5" STONE TEMPLATE.
SCALE OF FEET.


DETAIL No: 86
THE HOUSE.
TRUSSED PARTITION.
DETAILS OF JOINTS AT L, M AND N.
4"x4" BRACE.
JOINT AT N.
5½"x4" UPPER INTERTIE
4"x3" STUDS
PADSTONE
JOINT AT M.
4"x4" BRACE.
7"x4" COMPOUND HEAD AND CILL.
13½"x6¾"x3" PADSTONE.
4"x4" BRACE
5½"x4" WOOD LINTOLS
JOINT AT L.
5½"x4" LOWER INTERTIE.
PAD-STONE.
BRACE.
LOWER INTERTIE
WOOD LINTOLS
SCALE OF FEET.

In the upper part of detail No. 82 at C is shown a junction between the wall post, compound head and cill, and the longer brace of the top storey.

A parallel wall post is employed in this case, instead of the reduced post shown in the same detail at A, and applied to the similar position in the lower storey.

The joint at C is made close to the wall post but by housing the brace into the cill, while at A the brace is obliquely jointed by a single abutment and tenon to the post, and is of the same type as previously illustrated in roof truss construction. The former joint has a perfectly square thrust on the bottom shoulder and is easy to construct, a "bridle" joint being formed by forking the abutment and leaving a corresponding triangular tenon or cog upon the cill.

Detail No. 83 illustrates the junction between the heads of the braces and posts in the upper storey of the partition at positions marked D, E and F. The jointing is of similar character to the foregoing, with the addition of a shallow notch to fork over the bolt which passes on the left hand side of the post.

Detail No. 84 shows the joints at G in the outline diagram. On the left is illustrated the compound head and cill, with the relative positions of the intermediate posts and tension bolts and the necessary clearance between them. On the right is a detail of the joint where two braces give support to the centre of the beam. Centre line arrangement is adhered to and the struts are tenoned obliquely into the beam, abutting adequately upon a 4″ × 2″ straining piece which is spiked to the intertie.

Detail No. 85 gives the joints at the head and foot of the door post in the ground floor storey at H, J and K in detail No. 80. The foot joint may be either a common mortice and tenon or the form of bridle joint illustrated, where the forked end of the post is V shaped at the shoulders and a corresponding cog is formed upon the cill. The angles between the sides of the V should not be less than 90°.

282. Brace and beam joints, without wall posts. Suitable methods for jointing horizontal members and inclined braces are shown in details Nos. 85 and 86, applied to the head, cill and intertie of the partition.

The joint at N, No. 86, is another form of bridle joint suited to inclinations less than 45°. It has been previously explained in Vol. I.

If the square abutment is too near the end of the intertie for resisting shear—say, nearer than 4″—the joint may be treated as shown at L, where a piece is removed from the end of the brace to bring the shoulder to a safe distance. The lower, square angle, is then bridled as in No. 85 at K.

It is well to observe the difference in these joints. Neither is a perfect one because at N the thrust is transmitted through the upper half of the brace and at L through slightly more than half on the lower side. This is a common fault with timber joints which meet obliquely, and cannot be satisfactorily rectified; if made to abut squarely across the full width of the inclined piece, the sinking on the abutment changes shape with the shrinkage of the material. At the same time a square abutment of full width is theoretically the best and by using well seasoned material the change of shape should be small; but in unseasoned material this change of shape is often sufficient to allow the structure to deflect due to bearings of joints crushing into the material, as the abutment changes shape and throws the load on one edge.

Details Nos. 86, at M, and 85, at K, show the treatment recommended for braces which have a slope greater than 45°. The end can be cut off square to the length and the overlapping triangle across the full breadth bridled as shown. Because the horizontal component of the thrust in these braces becomes smaller as the inclination increases the joint may approach correspondingly nearer to the end.

283. Fixings for joints of partitions. When partitions are built upon the ground and erected bodily into position it is sometimes necessary to secure the feet of braces by foot bolts or straps in the absence of wall posts, and if the latter are employed, to connect them with straps or continuous bolts to the beams to avoid distortion of the frame in lifting.

If built in position this treatment is unnecessary, and as the latter procedure is recommended we have omitted such fastenings.

For the partition illustrated in the foregoing details, the whole would be set out and constructed in a horizontal position, then dissociated and built up as the work proceeds, and temporary support given to the cill until the tension bolts can be inserted and tightened.

284. Floor joists on partition. Floor joists could be placed in position at the completion of each storey and would facilitate the work of erection.

The joists of the bedroom floors are notched down 1″ upon the compound head and cill, as shown in detail No. 81, while the attic joists are specially provided for, as illustrated in the section at the upper corner of the same detail. Two sets of joists, $4\frac{1}{2}'' \times 2''$ and $9'' \times 2''$ respectively, rest upon the head, their upper surfaces being on the same level; this necessitates a $4\frac{1}{2}'' \times 3''$ packing which is set flush on the side of the shallower joists and leaves a 1″ seating for the deep joists on the opposite side. The latter are notched down to

$4\frac{1}{2}''$ broad so that $3''$ of length rest also upon the packing, and then the two sets of joists are interleaved across the partition, as shown in isometric projection.

285. Studs and nogging pieces. In preparation for the plasterer's laths, the framework of the partition is filled with $2''$ vertical studs at $14''$ centres, or less, according to the space to be filled. The studs generally have the same breadth in the direction of the thickness of the partition as the main framing and their width on face must not exceed $2''$ or the key of the plaster to the laths is interrupted too much. The same difficulty occurs at the faces of the main members and is overcome by (*a*) bevelling the edges of the laths to give a dovetailed hold to the plaster, or (*b*) studding the surface with clout-headed nails driven within $\frac{1}{4}''$ of the head.

Another method is to make the studs $\frac{1}{2}''$ thicker than the main framing, and to nail $\frac{1}{4}''$ laths as packings across the faces of the broad members at right angles to the direction of the general lathing, thus keeping the face laths from coming in contact with the main frame. This process is called "brandering".

The jointing of studs and the mode of stiffening them by horizontal nogging pieces at intervals are illustrated and explained in Vol. I.

Patent Partitions

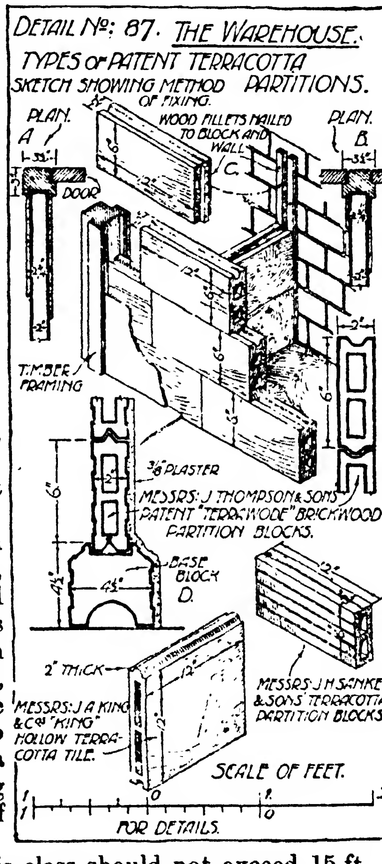
286. It is often necessary to divide the successive floors of a building into rooms of different size and shape, within the important vertical walls which continue throughout the height of the structure and support the floors and roof.

For such purposes special partitions are largely employed, supported upon the floors. To reduce the weight as much as possible these partitions are constructed of perforated or hollow blocks of brick and terra-cotta, thin plaster slabs or other suitable material which will provide the necessary rigidity and strength, while not unduly stressing the floors.

In many cases, steel beams are placed directly beneath such partitions for adequate support.

287. Terra-cotta partitions. Many forms of hollow terra-cotta block are obtainable, some of which are illustrated in detail No. 87. Some of these blocks are of porous material prepared and burnt so as to hold nails. They usually consist of $12'' \times 6''$ to $12'' \times 12''$ hollow slabs, perforated lengthwise, having an overall thickness of $2''$ to $4\frac{1}{2}''$ and a thickness of material from $\frac{5}{8}''$ upwards. The broader slabs have plain bed joints but the narrow ones are usually tongued, as shown in the detail, to increase the rigidity of the joints and make them less dependable upon the mortar bedding.

In elevation the blocks are placed like bricks in stretching bond so that the overlap is half the length. At angles, doorways, etc., grooved wood posts are employed, as shown at A and B in the detail, although external angles may often be satisfactorily bonded without the post. The grooves receive the ends of the blocks and two dovetailed rebates adjoining the groove receive the plaster and retain it at the edge.



Where a partition adjoins a brick wall a chase may be prepared in the latter to receive it, but the partition should not be bonded to the wall because the settlement will not be equal for the two parts of the structure. Another method is to fix two laths upon the wall to form a groove as shown at C, and to insert the tongued end of the block therein where the tongue is available, or to nail a strip of wood on the end to form a tongue, as shown in the detail, and in either case to bed or grout the joint in portland cement.

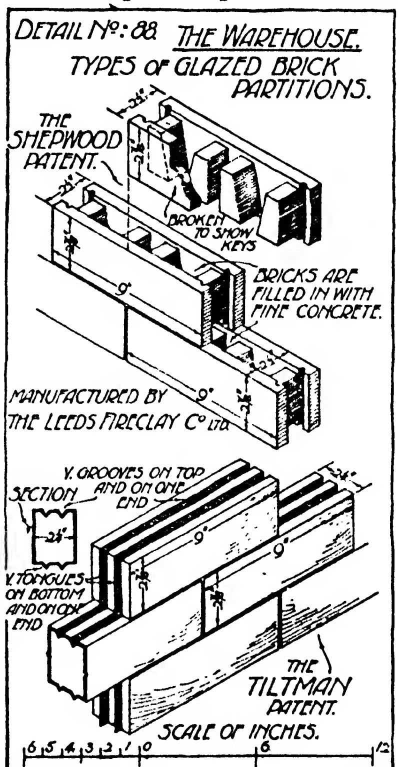
Base mouldings may be worked in hard plaster upon the flat face, or wood skirtings may be nailed direct to the partition blocks upon the ordinary plaster, which is continued to the floor; or again, special plinth blocks may be employed, as shown at D, to facilitate the formation of a plinth by laying and moulding a comparatively thin coat of plaster or cement.

The thinner partitions of this class should not exceed 15 ft. in length nor 10 ft. in height unless reinforced or otherwise supported by cross partitions.

288. Well-known terra-cotta partition blocks. Good terra-cotta blocks for partitions are supplied by Messrs J. A. King and Co. in three forms, viz. hard blocks keyed for plaster, nailing blocks, and keyed and self-faced blocks smooth on both sides. Another

well-known block, made from a material called "Terrawode-Brickwood", is manufactured by Messrs Jabez Thompson and Sons, Ltd. It is made in one uniform quality and takes nails anywhere, thus simplifying the fixing of joinery.

Messrs J. H. Sankey and Sons, Ltd., also produce partition blocks of porous terra-cotta which hold nails and are keyed for plaster, in addition to smooth faced blocks.



All the above blocks are fire-resisting and durable, and claim also to prevent the passage of sound. The latter quality varies considerably with the kind of material, the porous substances being more effective.

For a further note on porous brick and terra-cotta, see the chapter on Materials, paragraphs 621 and 622.

289. Glazed brick partitions. Some partition blocks are prepared for special use in divisions for factories, schools and public institutions, and for any other position where sanitary considerations are important. The Shepwood and Tiltman patent blocks, manufactured by the Leeds Fireclay Co., are good examples of this type.

The Shepwood block is 9″ × $2\frac{7}{8}$″ × $2\frac{1}{2}$″ thick measured externally, and consists of two $\frac{5}{8}$″ face slabs connected by four semi-dovetail diaphragms having a depth less than that of the block, and placed one near each end and two near the centre, as illustrated in detail No. 88. The inner surfaces of the face slabs have a semicircular key groove at each end. This arrangement allows the partition to be bedded in cement mortar and keyed horizontally and vertically by grouting with cement or packing with soft, fine concrete; the result is a strong partition, almost monolithic in character, which will, if necessary, carry its own weight over a considerable span.

Special blocks are made for bonding angles and junctions, and also

for stopped ends and coping courses. The ordinary and special blocks may be obtained in plain fireclay, plain white glazed or with ornamental surfaces; the unglazed material is very dense and smooth and practically non-absorptive and is suitable for sanitary partitions where economy must be considered.

Tiltman's partition blocks are solid bricks, $2\frac{1}{4}''$ thick, having their bed and vertical joints tongued together by double V tongues and grooves, as shown in the same detail. The blocks are laid in portland cement mortar made from one part of cement to one and a half or two parts of fine sand; the tongues produce a rigid partition and prevent the disturbance of single blocks. The partition is heavier than the Shepwood—which may be left partially hollow if desired—but this point is only of importance when the partition is designed to carry its own weight.

Detail No. 87 shows the method of using such blocks, which might be applied to divisions between W.C.'s in the warehouse lavatories.

290. Concrete block partitions. Concrete partition blocks, of solid or hollow form according to thickness, are in common use. They are made from portland cement and light aggregates such as coke breeze and pumice-stone, and other special and patent aggregates.

King's partition blocks are made solid from $2''$ to $4''$ thick, 3 ft. long and 1 ft. high; the $4''$ blocks are also obtainable of the hollow form.

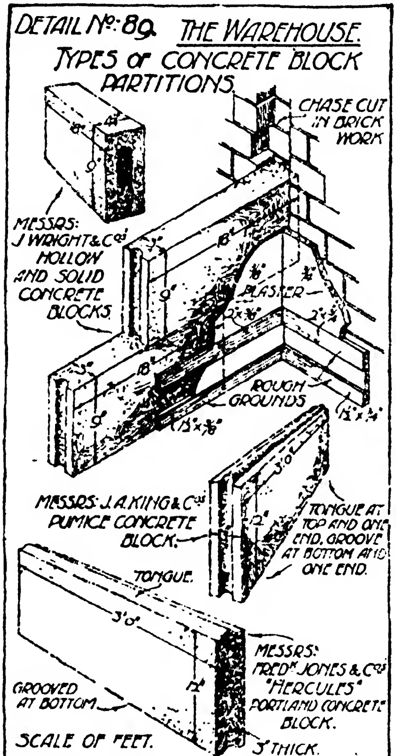
Wright's partition blocks are manufactured in thicknesses from $2''$ to $9''$, those from $2''$ to $3''$ thick being solid and $12'' \times 9''$ or $18'' \times 9''$ on face, with hollowed vertical edges for grout, or with tongued and grooved edges, while $4\frac{1}{2}''$, $7''$ and $9''$ blocks are made hollow, $18'' \times 9''$ on face and with square edges all round; a special aggregate is employed which is not liable to destruction by partially burning out in case of fire, a defect occurring in the use of coke breeze which renders it unsatisfactory for the most important fire-resisting construction.

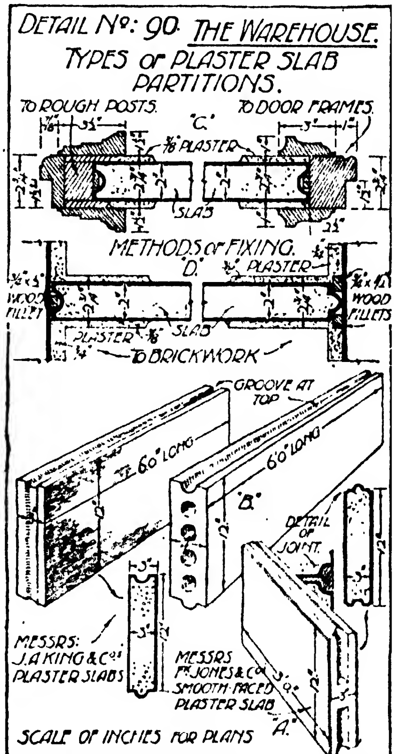
Concrete blocks are set in portland cement mortar or run with portland cement grout where the vertical joints require it. If well finished blocks are obtained and the joints neatly made the surfaces are quite satisfactory without the addition of plaster, for workshops and factories and other commercial structures.

Typical blocks with variable jointing are shown in detail No. 89.

291. Plaster slab partitions. These are somewhat similar to the thinner concrete slab partitions, but the matrix employed is plaster of Paris, or some other preparation of gypsum along with a light aggregate or coarse sand. Some slabs are almost entirely of plaster of Paris.

The plaster is generally weak and friable and for this reason the slabs are often reinforced and reduced in density by reeds or vegetable fibres embedded in the direction of their length when casting. The density of the thicker slabs is often further reduced by cylindrical perforations running horizontally; in other cases vertical perforations are employed which allow cement grout to be used for





improving the solidity of the partition. Usually, the slabs are merely bedded and jointed with ordinary hair mortar[1] gauged with plaster of Paris.

Most plaster slabs have some form of tongued and grooved joint or a double grooved joint to permit of grouting solid, others have end-locking devices for ensuring true alignment of the courses; special edge joints are necessary for thin partitions, as explained

[1] See Chapter on Materials.

in the preceding paragraphs, to give security to individual blocks and to increase the rigidity of the entire partition.

Plaster slabs are obtainable from 1½″ to 3″ thick, 12″ broad and 3 ft. to 6 ft. long. For important work the partitions are finished by a thin coat of fine or setting plaster; for work of less importance they may be neatly flush jointed with the original face exposed. Where intended for plastering a rough or keying surface should be provided.

Detail No. 90 shows a slab with self-finished surfaces at A, and at B a thicker perforated slab.

Horizontal sections at C and D in the same detail show how the slabs are secured and finished at door frames and brick or stone walls, by employing strips of wood secured to the abutting surface to form a tongue or groove as required. The joints are made at these positions by bedding the square portion in mortar and grouting the interstices solid with cement or liquid plaster wherever sufficient space exists.

Plaster slabs are easily cut to the required length for meeting odd dimensions by using a hand saw. As the severed portions may both be employed there should be very little waste in erecting a series of partitions.

292. Weight of concrete and plaster partitions. Slab partitions of the kinds described in the two preceding paragraphs have approximately the following average dead weights:

Thickness of partition	Weight per ft. super (unplastered)		
	Breeze concrete	Pumice concrete	Plaster concrete
1½″ solid	—	—	6½ lbs.
2″ ,,	12 lbs.	11 lbs.	8½ ,,
3″ ,,	17 ,,	15 ,,	12½ ,,
4″ ,,	20 ,,	18 ,,	—
4″ hollow	17 ,,	15 ,,	14 ,,

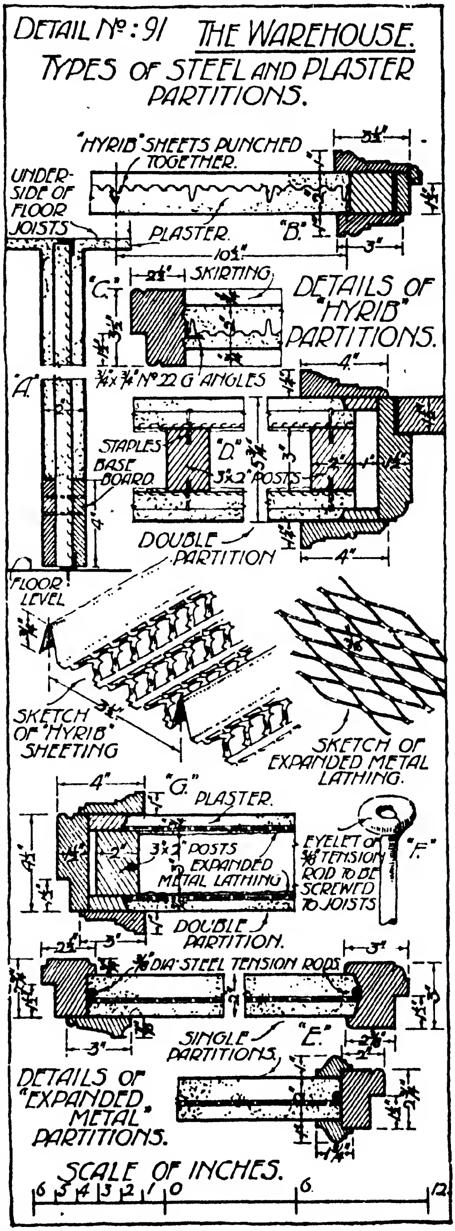
293. Steel and plaster partitions. Many thin partitions are erected by using a groundwork of steel mesh and covering one or both sides with plaster. To provide the key for plaster the steel sheets are cut and deformed, as shown in detail No. 91, and to give rigidity to what would otherwise be a flexible sheet, ribs are formed at intervals by crumpling the sheet.

294. Hy-rib partition. The particular type illustrated in the upper part of this detail is known as Hy-rib, manufactured by the Trussed Concrete Steel Co., and may be employed for vertical partitions,

ceilings or centering for concrete work. It is obtainable in sheets 6 to 12 ft. long by $10\frac{1}{2}''$ wide, having ribs $\frac{13}{16}''$ deep at $3\frac{1}{2}''$ centres running lengthwise of the sheet.

For single partitions, up to 12 ft. high, the Hy-rib is erected with the ribs vertical and in single lengths. Edge joints are made by lapping the edge ribs together and interlocking them at the lap by a special punch which perforates the sheets and prevents withdrawal. At the head and foot the Hy-rib is secured by steel clips or galvanised wire to small angle irons screwed to the floor and ceiling, as shown in the section A, detail No. 91, and further secured at vertical edges by nailing to door posts or wall, through the rib, as shown at B.

If the partition is so large that the material easily buckles, it is temporarily stiffened by timber scantling in horizontal positions across its back, and the flat face plastered to a thickness of about $\frac{3}{8}''$ and roughened before setting. The plaster should be composed of one part of portland cement to four parts of clean sand, by volume, with about 7 per cent. of lime and sufficient ox-hair to bind. When set, the temporary supports are



removed and the opposite surface plastered to a thickness of about $\frac{3}{8}''$ over the ribs, making a total thickness of at least $1\frac{1}{2}''$. Finishing coats of similar composition, but omitting lime and hair, are applied to a thickness of about $\frac{1}{4}''$ and trowelled to a smooth true face. Other surface finishes may be obtained by the use of fine lime plaster or one of the patent plasters in common use, making a finished thickness of 2″, as shown in the detail.

295. Wood framing to doorways in partitions. In the same detail, at B and C, are shown methods of constructing linings and posts to doorways in single partitions. At B a 2″ rough post is employed to receive the Hy-rib and plaster, and the linings and finishings are added after the plastering is complete.

In the section at C a $3\frac{1}{2}'' \times 2\frac{1}{2}''$ wrought and moulded door frame is used, splay-housed to receive and hold the plaster, and projecting from the surfaces of the latter to allow the $\frac{3}{4}''$ skirtings to finish flush with its faces; a light steel angle is screwed to the back of the frame for the purpose of clipping or wiring the edge of the Hy-rib.

To secure wooden skirtings to the bases of these partitions $\frac{5}{8}'' \times 4''$ to 6″ pieces are placed against the face and back of the Hy-rib, upon the floor, and screwed to each other from opposite sides, as shown in the lower section at A in the detail.

296. Hollow block partitions. If a partition is to be thicker than 2″, owing to its dimensions, its need to resist sound, or for other reasons, it may be constructed with a cavity, as shown in the same detail at D. In this detail the cavity is 3″ wide and the support for the two layers of Hy-rib is provided by $3'' \times 2''$ vertical studs placed at 5 to 6 ft. centres; the steel sheets are placed with their ribs in a horizontal direction and may be secured by galvanised staples or nails.

297. Steel partition supports. Instead of timber studs, light steel channels or **I** sections may be run between floors with ceiling pieces of the same form, and the cavity may then be as small as $1\frac{1}{2}''$ for partitions 10 ft. high, or 2″ for a height of 12 ft. Special rib-studs are also made for the same purpose as the channels and have the advantage of lightness in addition to allowing the free passage of pipes and wires between the two layers of plaster.

298. Expanded metal partition. Ordinary expanded metal lathing —as supplied by the Expanded Metal Co., Ltd.—is in common use for the construction of partitions.

For solid partitions, $\frac{3}{8}''$ diameter round iron tension rods, as shown at E, are placed vertically at 12″ to 14″ centres and secured to timber floor framing by screws through eyelet ends, as at F, or to steel beams and ceiling bars by special clips; $\frac{3}{8}''$ diamond mesh

or cup mesh lathing is wired to the rods and at laps and edge joints in the sheets. A $\frac{1}{2}''$ coat of hair plaster is laid on each face of the lathing—temporarily strutted, as explained in the previous paragraph for Hy-rib lathing—scratched for key before setting, then finished with finer coats of plaster without hair. While properly covering the tension rods the partition may be finished $1\frac{5}{8}''$ thick, or even less if desired.

Where double partitions are required, as at G, similar studs to those employed for Hy-rib may be used, viz. of timber, steel angles or steel channels. Instead of the channels two angles are often employed with flat bar distance pieces riveted across them at 2′ 6″ to 3′ 0″ intervals, short pieces of transverse angle steel being substituted for these at the head and foot to facilitate fixing. Wood skirtings are secured to grounds fixed to short vertical blocks of timber which are clasped in the cavity between the sheets of expanded metal.

299. Preservation of metal lathing or reinforcement. When metal lathing such as expanded steel or Hy-rib is employed in building construction it is invariably coated with some preservative to prevent corrosion before use and also when used with a permeable plaster covering. Such sheets always suffer some damage in transit and handling and in many cases little of the preservative remains at the time of enclosure.

For this reason portland cement plaster should be used in preference to ordinary lime plaster for the initial covering because the preservative action of the cement on steel is more dependable and the action is assisted by a slight initial oxidation of the enclosed metal.[1]

Lime plaster and gypsum cements allow the mixing water and absorbed moisture to attack the steel, the former causing speedy oxidation and the latter continuing the process slowly.

300. Hollow and perforated bricks of standard size. Several types of bricks are produced of standard size, that may either be used for an entire structure or for compounding as required with ordinary bricks. Their primary intention is to reduce weight.

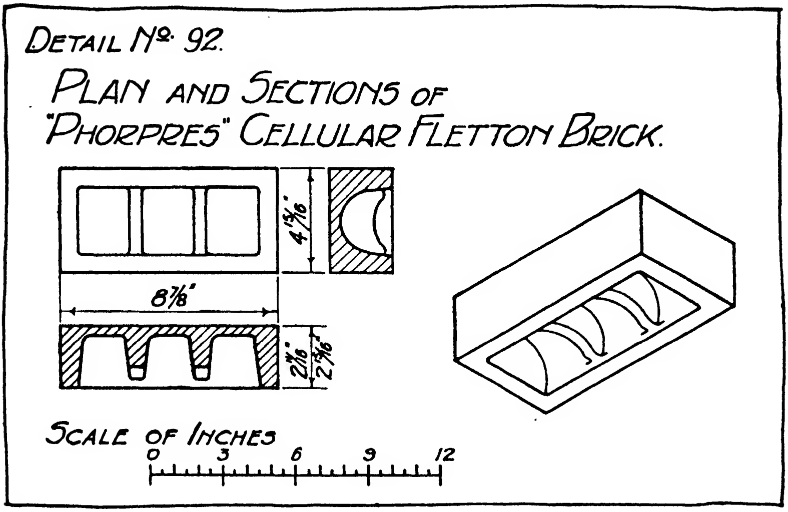
The Phorpres Cellular Fletton brick is one of the best known of the cellular types. Its form and dimensions are given in detail No. 92. Because of the hollow or cellular structure the weight is reduced to about 75 per cent. of that of a solid wall in similar material.

At the same time the strength of the wall is found to be ample for all the ordinary purposes of building construction.

[1] See Chapter on Materials.

The brick is built in the position shown in the sketch with the hollowed face downwards.

It is claimed for this brick that heat transmission and absorption of moisture are both reduced, and that sound transmission is markedly reduced.



The uses of the brick are:

For internal and external walls, partitions, facings and all general purposes excepting work below ground.

The sizes are standard, the two thicknesses available are intended to provide for *four courses to* 12" or *four courses to* 13" as desired.

The bricks may be obtained with plain finish, or keyed for plaster, or rustic for facings.

Other bricks prepared with a view to reducing weight are generally perforated through the thickness with round holes, and the reduction of thickness of material exposed to the heat of the kiln makes for better and sounder burning.

One objection is often raised by architects and builders to the use of cellular bricks, viz. the difficulty of obtaining sound and reliable fixing by wood plugs. It is difficult to drill plug holes without damaging the bricks, and insecure fixing often occurs. If proper precautions are taken, however, and the carpenter is aware of the nature of the wall, much of this objection can be overcome. Where heavy fixings are required some special provision should be made for the purpose.

301. Armoured plywood and fibre boards. Wooden studded partitions may be constructed in the ordinary way, and finished by covering with large sheets of armoured plywood or fibre board.

Thin facings of hard fibre, copper, steel monel metal, or stainless steel are cemented to the face of the above-named materials and are secured by nailing or screwing to the wooden framing. The joints, which are not too numerous, are protected by special moulded and metal covered strips.

These armoured sheets are used for partitions in sanitary conveniences and in hospital work. Monel metal is very suitable, having a bright finish which is not affected by disinfectants and easily kept clean by washing.

The hard fibre finish is varied in colour and needs no paint. It is smooth and durable and can be used for many purposes besides partitions.

Fibre insulating boards are also available, the fibre being prepared in thick, open cellular form.

302. Defects of light partitions. While light weight partitions have distinct advantages in reducing the load on a structure and in their use for dividing a large floor area into compartments by erecting directly upon the floor, they also have disadvantages. Many of them convey sound unduly and most of them present difficulties in fixing woodwork and fittings, where plugging has to be done. In all cases, special provision for fixing should be made, otherwise hollow bricks, terra-cotta blocks and the like may be shattered by attempting to insert wooden plugs in unsuitable positions—unknown to the craftsman who is called upon to execute the fixing.

CHAPTER THIRTEEN

TEMPORARY CARPENTRY

Centering

303. In the arches of the warehouse the spans are larger, with a greater proportionate load to be borne during construction than was the case with the elementary examples applied in Vol. I. The walls in which these arches occur are much thicker owing to the increased height of the structure and the provision for greater floor loads.

304. Principles of centering. The same governing principles must apply to these structures as were previously stated in Vol. I. Briefly, these may be summarised as follows:

A temporary curved support is required which shall be:

(*a*) Economical in form, material and labour.

(*b*) Rigid enough to bear the temporary load without appreciable change of form.

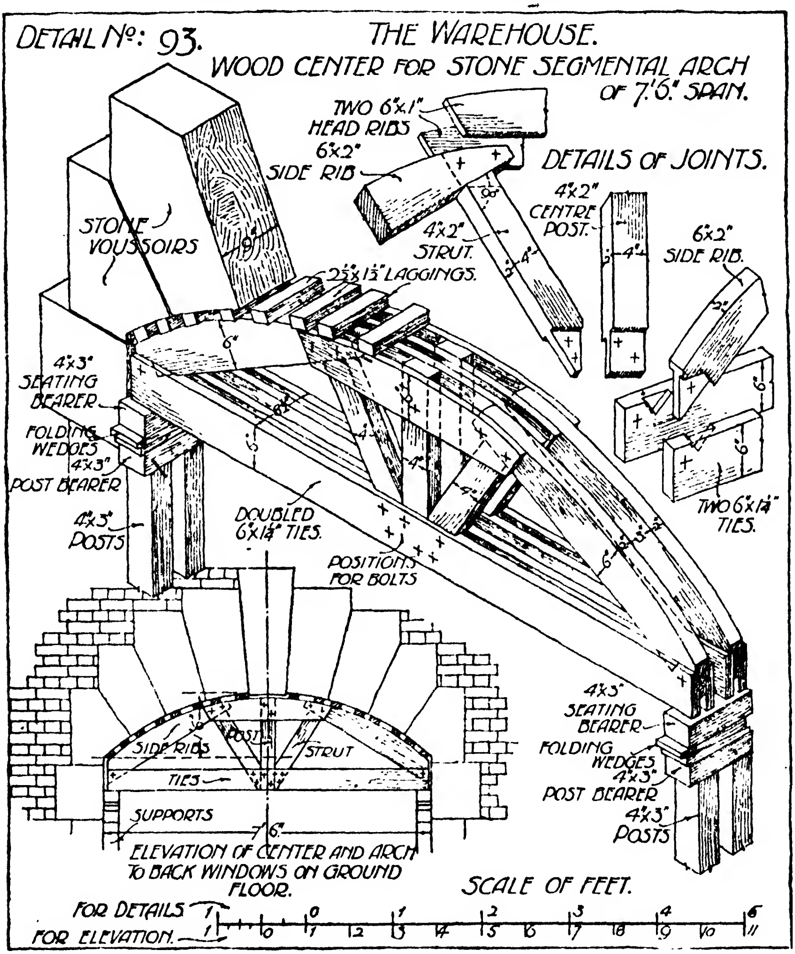
(*c*) Capable of vertical adjustment to allow for easing off the load when the arch is complete.

(*d*) Easily dissembled to allow of the employment of the material for other temporary purposes.

305. Segmental centers to ground floor back windows of warehouse. The ground floor back window openings are 7′ 6″ span and 1′ 6″ rise and are spanned by stone segmental face arches, 9″ long on soffit and about 2 ft. deep on the face. Detail No. 93 illustrates a form of center suitable for their support.

The dead weight of stonework is in this case considerable and the thin built-up ribs previously adopted are scarcely stiff enough; 2″ material is therefore employed for the rib segments, clasped together at the centre by pairs of 6″ × 1″ gussets or head ribs and held at the springing by 6″ × 1¼″ double ties. To prevent deformation of the arc of curvature, struts are placed square to the soffits of the end segments and also a vertical post at the centre. The joints at the head of the splayed struts are formed by lapping the 1″ gussets completely across the joint and bolting them through the ribs, thus casing in to prevent movement while providing a square support. At the feet of the struts and post, tenoned joints are formed, thereby allowing the ties to approach closer together but leaving a 1″ or

$1\frac{1}{8}''$ space for the tenons to enter. A similar joint is made between the foot of the side rib and the ties, with the addition of square shoulders 2″ deep on the face and housed $\frac{1}{2}''$ into the face of each tie; effective resistance to thrust is thus obtained.



306. Securing joints in ribs of centers. Joints between the members of this center are conveniently made by using $\frac{1}{2}''$ diameter screw bolts of the required lengths; the positions for these are shown by small crosses. At the completion of the work, the bolts may be unscrewed and re-used for any suitable purpose, leaving the material free from nails.

307. Assemblage of parts of center. The complete center consists of two ribs or vertical triangulated frames placed parallel to the face of the wall, and connected by $2\frac{1}{2}'' \times 1\frac{1}{2}''$ laggings placed one near each edge of each voussoir on the soffit of the arch, excepting under the key stone which projects below the general soffit line and needs no support.

Seating pieces, bearers, posts, folding wedges for supporting and adjusting the center are necessary to the completion of the structure, as previously shown in Vol. I, and further illustrated in this detail.

308. Support to back arch. The stone face arch is backed by a rough brick arch in three $4\frac{1}{2}''$ rings and $13\frac{1}{2}''$ long on the soffit, making a total length equal to the thickness of the wall. The rough arch has its soffit parallel to that of the face arch but 3″ higher to form a head rebate for the sash frame. A separate center should be provided for the back arch if the arches are to be set in slow setting mortar so that each may settle gradually and independently under the accumulating load of walling. This is necessary because the back arch with its numerous mortar joints will compress and settle much more than the face arch. It is unnecessary to illustrate this case because the arrangement is identical with that shown in Vol. I for the cottage doorway, where the separate centers, with independent adjustment for "easing" and "striking", are supported on one set of bearers and posts.

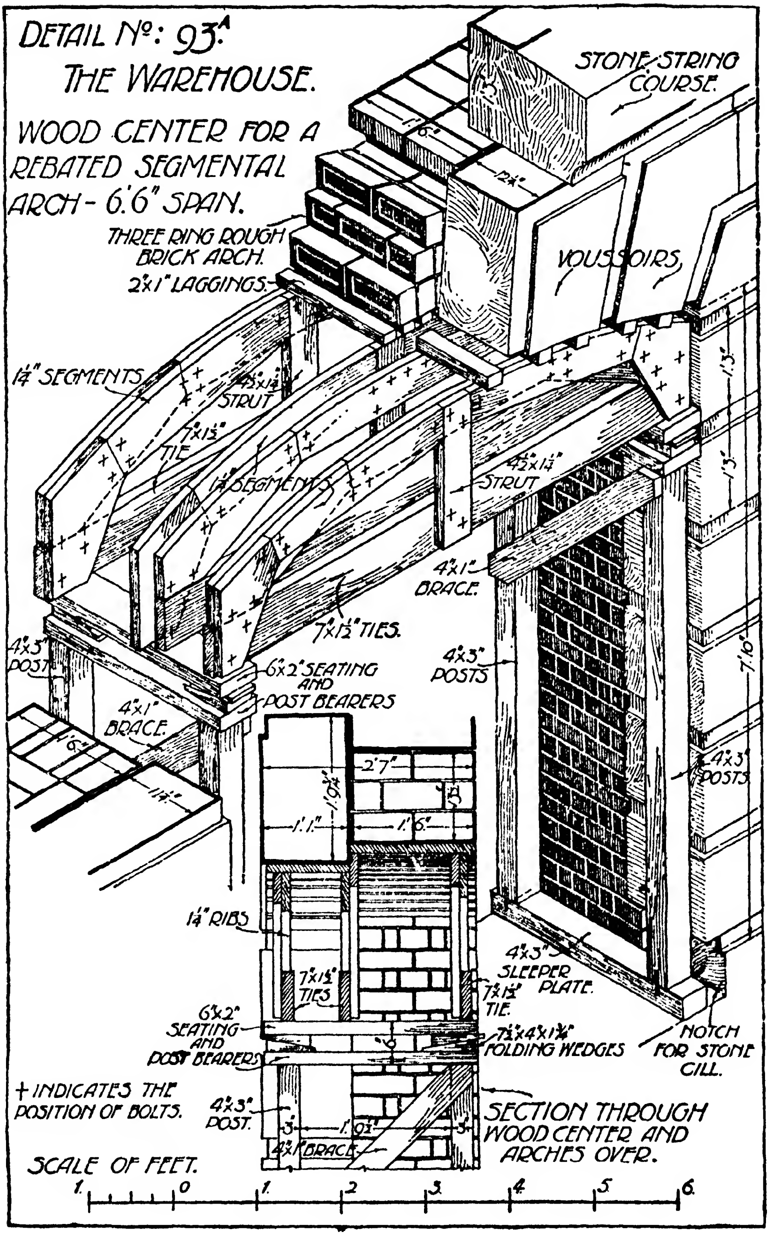
An alternative method, applicable to special cases, is shown in detail No. 93 A, and explained in the succeeding paragraph.

Should the designer prefer the brick backing to be carried upon steel or cast iron girders, the back center would not be required, and the detail of No. 93 would apply exactly as shown.

309. Segmental center to ground floor front windows of warehouse. When the span and weight of an arch make it feasible a thin ribbed built-up center may be employed as shown in earlier examples (see Vol. I). Detail No. 93 A illustrates such a center for the front window arches on the ground floor of the warehouse.

The openings are 6′ 6″ span with segmental stone arches having a rise of 8″, and reveals and soffit 12″ wide; the face arch, 1′ 9″ deep at the crown, is backed by a three ring brick arch as described for the back window openings in the previous paragraph.

If set in cement, or other quick setting mortar, the front and back arches may be supported on one compound center, as shown in the detail. There are three ribs to support the laggings, those at the front and back being built to the respective curvatures of the front and back arches, while the middle rib has one section cut to the larger curve and the other to the smaller, these corresponding to the outlines of the front and back ribs,


DETAIL Nº: 93A
THE WAREHOUSE.
WOOD CENTER FOR A REBATED SEGMENTAL ARCH - 6'6" SPAN.
STONE STRING COURSE.
THREE RING ROUGH BRICK ARCH.
2½"x1" LAGGINGS.
VOUSSOIRS.
1¼" SEGMENTS
4½"x1¼" STRUT
7"x1½" TIE
1¼" SEGMENTS
4½"x1¼" STRUT
4"x1" BRACE.
7"x1½" TIES.
4"x3" POST
6"x2" SEATING AND POST BEARERS
4"x3" POSTS
4"x1" BRACE.
4"x3" POSTS
1¼" RIBS
7"x1½" TIES
4"x3" SLEEPER PLATE.
7"x1½" TIE.
6"x2" SEATING AND POST BEARERS
7½"x4"x1¼" FOLDING WEDGES
NOTCH FOR STONE CILL.
+ INDICATES THE POSITION OF BOLTS.
4"x3" POST.
4"x1" BRACE
SECTION THROUGH WOOD CENTER AND ARCHES OVER.
SCALE OF FEET.
1 0 1 2 3 4 5 6

The two-ply construction of the ribs is very suitable for this arrangement and enables very simple detail to be employed for the joints, which are merely lapped and secured with ½″ diameter screw bolts. The segments are cut out of 6″ × 1¼″ material or from wider stuff if the curvature requires it; while the laggings are of 2″ × 1″ material, two being provided for each voussoir of the face arch, and those for the back arch spaced circumferentially at about 1″ apart.

Such a center as we have described is in common use for arches having little rise, and with careful support and judicious easing and striking is quite satisfactory. The center should be sufficiently withdrawn or "eased" to relieve it of any weight, so that each arch may settle independently but without distortion.

Shuttering for Concrete Construction

Temporary woodwork for the support and reception of concrete is variously known as shuttering, form work or false work and, if applied to arched construction as in vaults and domes, is also called centering.

Shuttering for Concrete Lintols

310. Lintols cast in situ. Detail No. 94 shows a method of shuttering for the reinforced concrete lintol to the main entrance doorway of the house.

It consists of a two-sided box, the bottom of which is made of 1″ tongued boards and the side or face board of 1¼″ stuff.

To avoid the use of posts, 3″ × 2″ horizontal bearers are inserted in recesses left in the jambs, a few courses below the lintol, and wedged tight.

Upon these, 3″ × 2″ cross bearers receive 6½″ × 2″ packing bearers, which support the base boarding, the face board being held in position by 4″ × 1½″ brackets nailed to the cross and packing bearers.

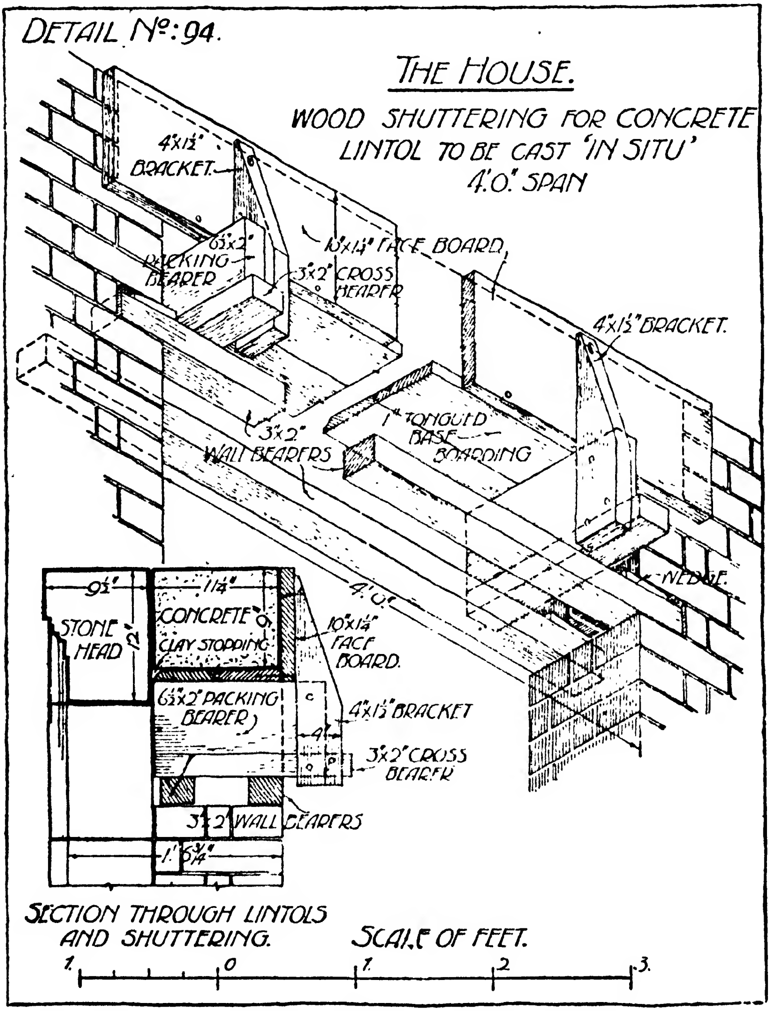
The face board should overlap the edge of the brickwork beyond the bearings and clay stopping is placed at the inner angle of the base, which is bevelled to receive it.

Detail No. 95 shows an alternative method in which the support is derived by posts resting upon the ground or brickwork beneath the doorway.

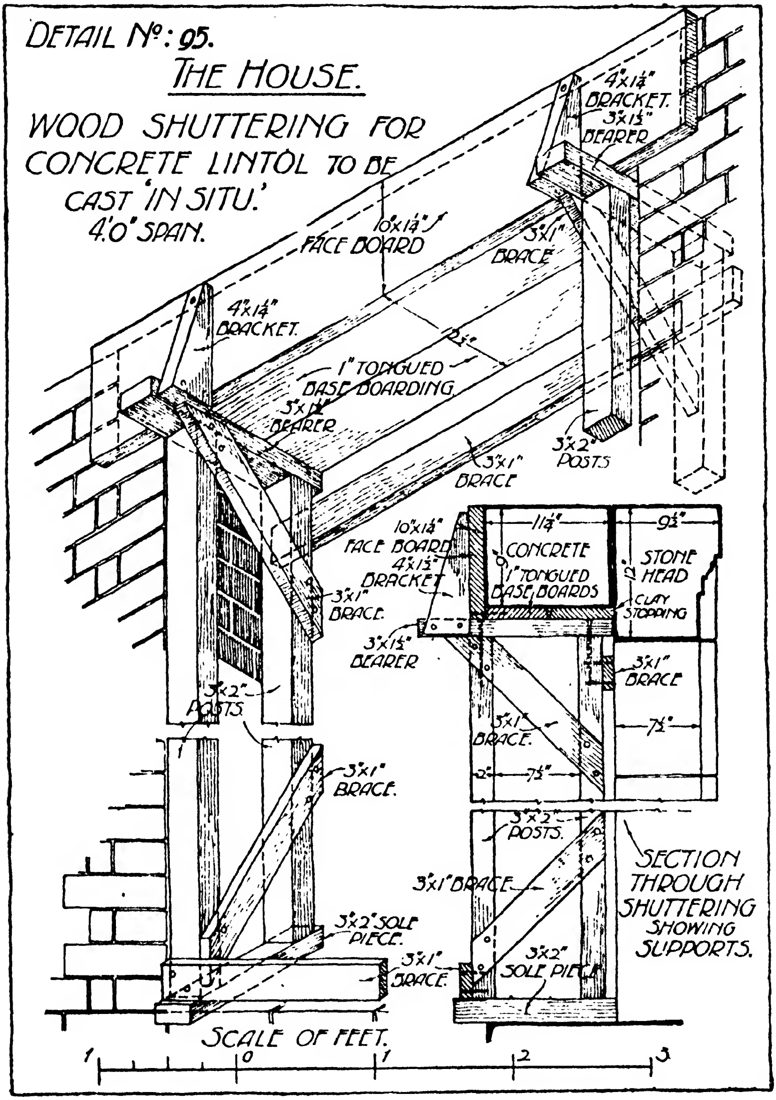
Slight variations are made in detail, as shown in the drawing and the posts are lightly braced and tied for obtaining sufficient rigidity.

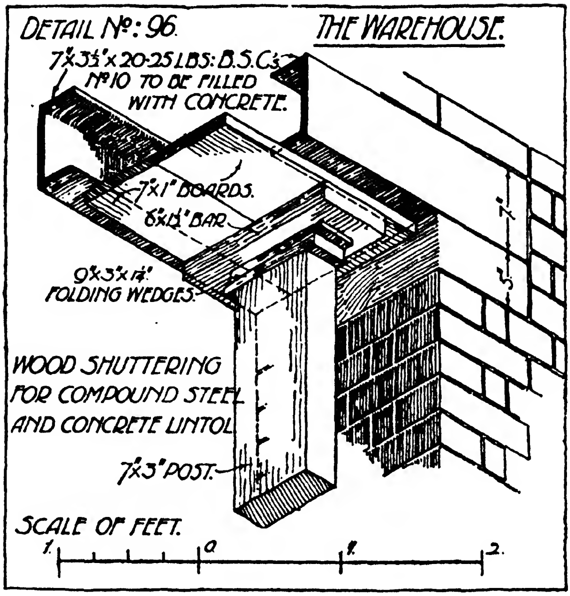
311. Concrete-filled lintol. When a lintol is composed of steel or cast-iron sections it is often wise to fill the spaces between the

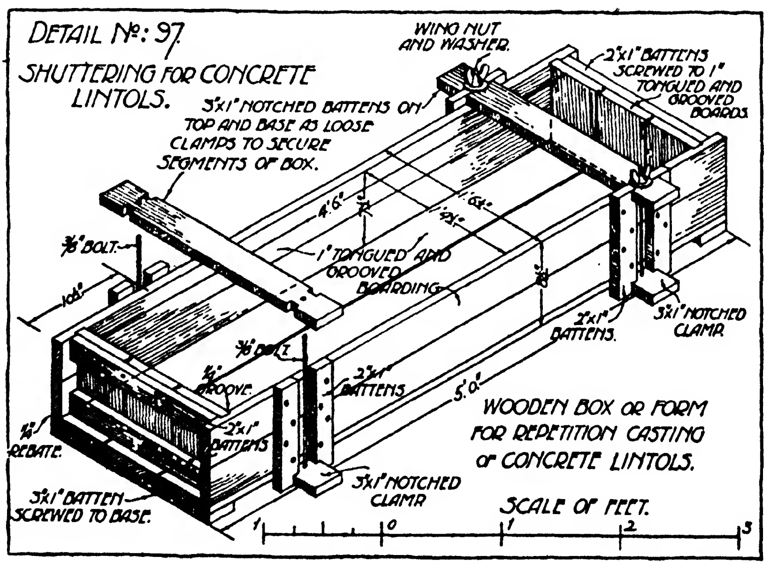
sections with concrete. For this purpose, all that is then necessary is to provide a battened shutter supported by vertical posts and tightened by wedges, as in detail No. 96.



312. Form for repetition casting of concrete lintols. A "form" or box for repetition casting is shown in detail No. 97. This is made with loose battened sides, ends and base, the sides and ends being grooved together and fitting loosely for easy withdrawal. The form


DETAIL No: 95.
THE HOUSE.
WOOD SHUTTERING FOR CONCRETE LINTOL TO BE CAST 'IN SITU.'
4'0" SPAN.
4"x1¼" BRACKET.
3"x1½" BEARER
10"x1¼" FACE BOARD
3"x1" BRACE
4"x1¼" BRACKET.
1" TONGUED BASE BOARDING.
3"x1½" BEARER
3"x1" BRACE
3"x2" POSTS
10"x1¼" FACE BOARD
4"x1½" BRACKET
3"x1" BRACE.
3"x1½" BEARER
3"x2" POSTS
3"x1" BRACE.
3"x2" SOLE PIECE.
3"x1" BRACE
11¼"
CONCRETE
1" TONGUED BASE BOARDS
9½"
STONE HEAD
CLAY STOPPING
3"x1" BRACE
3"x1" BRACE.
7½"
2"
7½"
3"x2" POSTS.
3"x1" BRACE
3"x2" SOLE PIECE
SECTION THROUGH SHUTTERING SHOWING SUPPORTS.
SCALE OF FEET.
1 0 1 2 3


DETAIL Nº: 96.
THE WAREHOUSE.
7"x3½"x 20-25 LBS: B.S.C's Nº10 TO BE FILLED WITH CONCRETE.
7"x1" BOARDS.
6"x1½" BAR.
9"x3"x 1¼" FOLDING WEDGES.
WOOD SHUTTERING FOR COMPOUND STEEL AND CONCRETE LINTOL
7"x3" POST.
SCALE OF FEET.
1.
0
1.
2.


DETAIL Nº: 97.
SHUTTERING FOR CONCRETE LINTOLS.
WING NUT AND WASHER.
2"x1" BATTENS SCREWED TO 1" TONGUED AND GROOVED BOARDS.
3"x1" NOTCHED BATTENS ON TOP AND BASE AS LOOSE CLAMPS TO SECURE SEGMENTS OF BOX.
⅜" BOLT.
1" TONGUED AND GROOVED BOARDING.
2"x1" BATTENS.
3"x1" NOTCHED CLAMP.
⅜" BOLT.
¼" GROOVE.
2"x1" BATTENS
¼" REBATE.
2"x1" BATTENS
3"x1" BATTEN SCREWED TO BASE.
3"x1" NOTCHED CLAMP.
5'.0"
WOODEN BOX OR FORM FOR REPETITION CASTING OF CONCRETE LINTOLS.
SCALE OF FEET.
1
0
1
2
3

is secured after assembling by pairs of loose notched clamps, which are gripped by $\frac{3}{8}''$ bolts with wing nuts and washers.

If such a box is to be continually used the battens must be placed so as to obtain strength and rigidity and should be fixed to the boards by stout screws.

Where steel reinforcement is introduced arrangements must also be made for notched supports and spacers to keep the rods in correct position until secured by the concrete filling.

The dimensions in the illustration are suitable for the reinforced back lintol to the basement doorway of the house and, by shortening the length, would serve for the windows on each side of it.

CHAPTER FOURTEEN

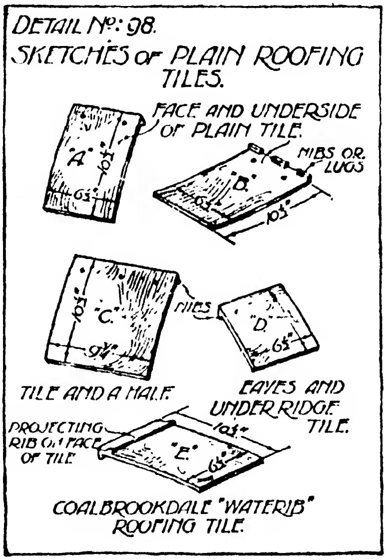
ROOF COVERINGS

Plain Tiling

Ordinary roofing tiles are artificial slabs of earthenware, used for the surface coverings of sloping roofs.

A description of the various classes of tiles in general use is given in the Chapter on Materials.

313. Kinds of roofing tiles. There are many kinds of roofing tiles in modern use, varying in shape and also in the nature of the material employed. Tiles made from brick earths have much greater architectural value than the asbestos-cement and other similar tiles which are now largely employed for reasons of economy. The best known tiles are "plain" and "pantiles", the former being in more common use.



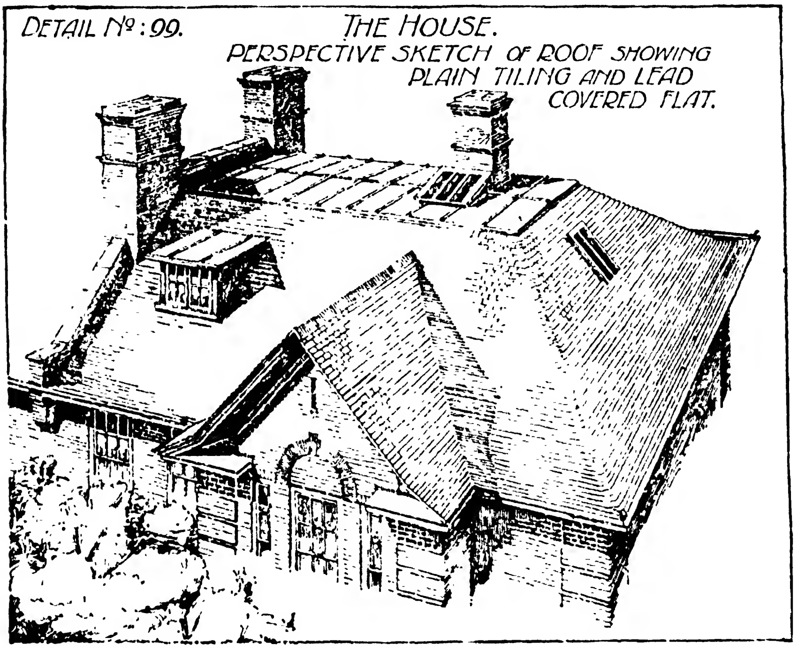
314. Plain tiles. Plain tiles may be compared to natural slates in their general shape and mode of laying. Usually they are slightly concave slabs of dense material $10\frac{1}{2}''$ long, $6\frac{1}{2}''$ wide and $\frac{3}{8}''$ to $\frac{1}{2}''$ thick. Their concavity is upon the *bed* and only in the direction of their length, and the object is defined in paragraph 318.

These tiles may be obtained either perfectly plain, with nail holes for fixing like slates, or with nibs moulded upon their heads and projecting downwards to hook over tiling laths, as shown in detail No. 98 at A and B. Most plain tiles are now provided with both nail holes and nibs.

To avoid the cutting of tiles, special lengths and widths are made, thus, "under eaves" and "under ridge" tiles have a length of $6\frac{1}{2}''$ to $7''$ and "verge tiles", known as "tile and a half", have a width of $9\frac{3}{4}''$ to $10\frac{1}{2}''$. Verge and eaves tiles are shown at C and D in the detail.

In the same detail an improved form of tile is shown at E, having a cross rib near the head and on the face side; the rib prevents water and snow being driven over the head of the tile. This tile is known as the "Waterib" tile and is manufactured by the Coalbrookdale Co., Ltd.

Some modern manufacturers produce tiles of a larger size, averaging 11″ × 7″ and ½″ to ⅝″ thick, having a rough or rusticated texture and variable tones which add to the architectural value of the roof covering.



315. Tiled roof to the house. A general idea of the roof covering required for the roof of the house may be obtained from the perspective detail No. 99.

The various methods of tiling which are described in subsequent paragraphs may be considered as alternatives for application to the house roof.

316. Preparation for laying plain tiles. Plain tiles are commonly laid (*a*) upon horizontal wooden tiling battens, (*b*) upon close boarding, (*c*) upon horizontal and counter-battens over close boarding. The battens may be used alone or may be laid directly upon close boarding, or again, sarking felt may be placed between boards and battens, as described for slating in Vol. I.

Reference was made in Vol. I to the possibility of leakage through broken slabs and also to the probability of fine snow drifting under the slates and lodging behind the horizontal battens when these are laid directly upon the felt or close boarding. Rain-water and melted snow may thus find their way through the nail holes under the battens, such moisture tending to rot the woodwork and being most liable to do so where felt is employed, because evaporation is slow.

The safeguard against this occurrence is to employ raking or counter-battens 12" apart up the slope of the roof, nailed to the close boarding over the felt, and to place the horizontal tiling battens across these, as shown in detail No. 100 at A; the latter are then clear of the boarding and felt, and any leakages have a free course down the felted surface to the eaves gutter.

317. Tiling battens. These are usually from $1'' \times \frac{3}{4}''$ to $1\frac{1}{2}'' \times 1''$, the smaller sizes being employed for closely spaced rafters or where nailed upon close boarding.

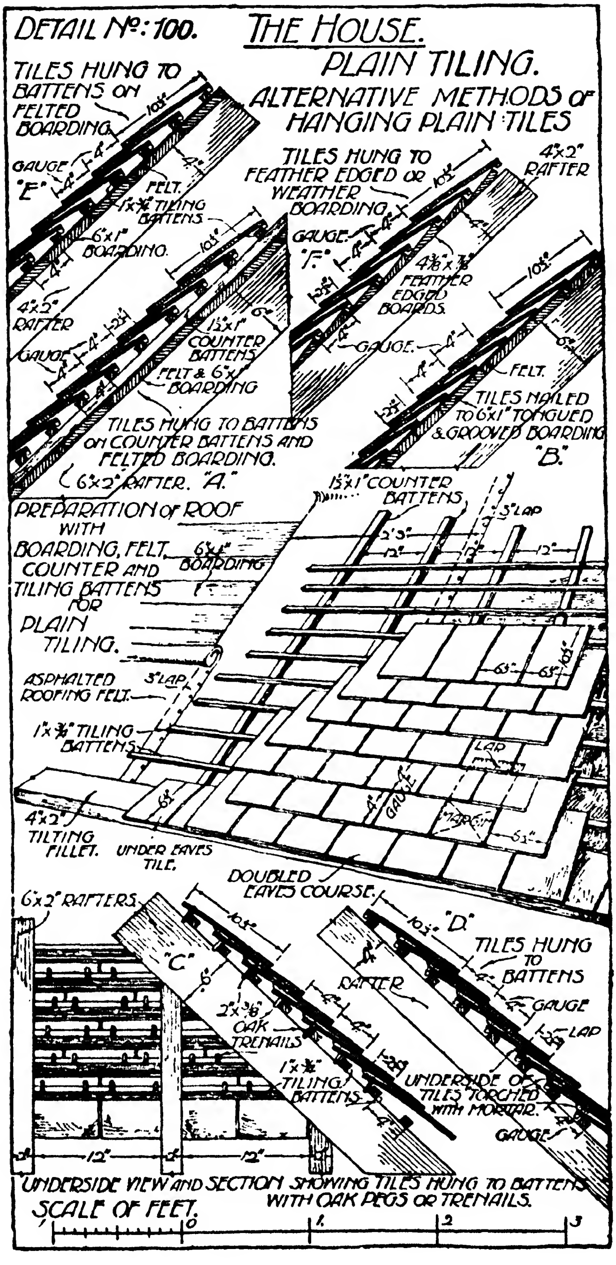
Counter-battens, where required, may be of the same dimensions as the tiling battens, or a little larger, and are commonly of $2'' \times 1''$ sawn fir or oak; all battens should be cut from straight grained material.

318. Lap and curvature of plain tiles. Plain tiles are laid in a manner similar to slates but with a shorter lap, the latter being generally $2\frac{1}{2}''$ for a pitch of 45°. The gauge of the tiling is therefore $\frac{10\frac{1}{2}'' - 2\frac{1}{2}''}{2} = 4''$, which is also the gauge of the battens.

This arrangement can be varied with circumstances and a greater lap employed if it is found necessary to use the tiles for a lower pitched roof in an exposed position. The flattest pitch for a $2\frac{1}{2}''$ lap under any circumstances is about 36°, but tiles are more suitably employed on pitches from 45° upwards. It is obvious that increase of lap is accompanied by a decrease of covering power to a much greater percentage per tile than with slates, which are so much larger.

The curvature of tiles is intended to assist close bedding of the tail of each tile upon its predecessor, and is a necessary precaution because it is impossible to guarantee a perfectly flat tile which would bed truly throughout its length. The concave bed thus induces close contact between the courses and reduces to a minimum the free access of wind between the tiles.

319. Methods of laying and fixing plain tiles. If plain tiles are to be laid directly upon a boarded or felted surface they must be supplied without nibs and nailed like slates, as shown in detail No. 100 at B, in which case every tile is secured by two zinc or


DETAIL Nº: 100. THE HOUSE.
PLAIN TILING.
ALTERNATIVE METHODS OF HANGING PLAIN TILES
TILES HUNG TO BATTENS ON FELTED BOARDING
GAUGE "E"
FELT.
1"x3/4" TILING BATTENS
6"x1" BOARDING.
4"x2" RAFTER
GAUGE
1 1/2"x1" COUNTER BATTENS
FELT & 6"x1" BOARDING
TILES HUNG TO BATTENS ON COUNTER BATTENS AND FELTED BOARDING.
6"x2" RAFTER. "A."
TILES HUNG TO FEATHER EDGED OR WEATHER BOARDING
4"x2" RAFTER
GAUGE. "F."
FEATHER EDGED BOARDS.
GAUGE.
FELT.
TILES NAILED TO 6"x1" TONGUED & GROOVED BOARDING "B."
PREPARATION OF ROOF WITH BOARDING, FELT, COUNTER AND TILING BATTENS FOR PLAIN TILING.
6"x1" BOARDING
1 1/2"x1" COUNTER BATTENS
3" LAP
ASPHALTED ROOFING FELT.
3" LAP
1"x3/4" TILING BATTENS.
4"x2" TILTING FILLET.
UNDER EAVES TILE.
DOUBLED EAVES COURSE.
LAP
GAUGE
6"x2" RAFTERS.
"C"
2"x3/8" OAK TRENAILS
1"x3/4" TILING BATTENS
"D"
TILES HUNG TO BATTENS
RAFTER
GAUGE
LAP
UNDERSIDE OF TILES TORCHED WITH MORTAR.
GAUGE
UNDERSIDE VIEW AND SECTION SHOWING TILES HUNG TO BATTENS WITH OAK PEGS OR TRENAILS.
SCALE OF FEET.

composition nails. Where nails are driven through a felt covering, leakages through the holes may occur.

It is sometimes desired to lay similar tiles upon battens, in which case they may be secured by oak pegs driven through holes specially provided and larger than would be required for nailing; the pegs form a projection which allows the tile to hang behind the batten. The method is an old one and not very common in modern work, but is illustrated at C. It is unsatisfactory in exposed positions.

The most common method of securing tiles on a roof is to adopt "nibbed tiles" and to hang them over the battens, which are nailed directly to the rafter, as shown at D, or upon boarding as at E.

Another method of preparing for and hanging tiles is shown at F, where feather-edged boards are employed. Their width must equal the gauge of the tiling—usually 4″—and the thick edges are required at the higher level, thus forming a continuous ledge to receive the tile nibs. This method is an economic form of close boarding and battens combined, and provides a warmer interior than battens only, but has the objection that driven rain or snow which may find its way through the tiles is retained on the sunk portions of the boarding and quickly penetrates to the interior.

The edges are not usually rebated for overlap, as shown in the detail, though this improves the insulating qualities of the covering.

It should be specially noted that close boarding prevents the back joints of the tiles being pointed or "torched",[1] which is no longer necessary as draughts cannot penetrate the interior. Torching should not be presumed to assist greatly the lap of the slates in weather-proofing against rain, though it does effectively resist driven snow and wind if properly performed.

Tiles should never be bedded on straw or heather, as is sometimes done, since this practice leads to insanitary conditions.

320. Plain tiling at eaves of roof. The eaves of a plain tiled roof is treated in a manner similar to that of a slated eaves, as illustrated in detail No. 101 at A, by the insertion of a double course, the lower tiles or under eaves course breaking joint longitudinally with the upper one and lapping underneath the second visible course to the specified extent of $2\frac{1}{2}''$.

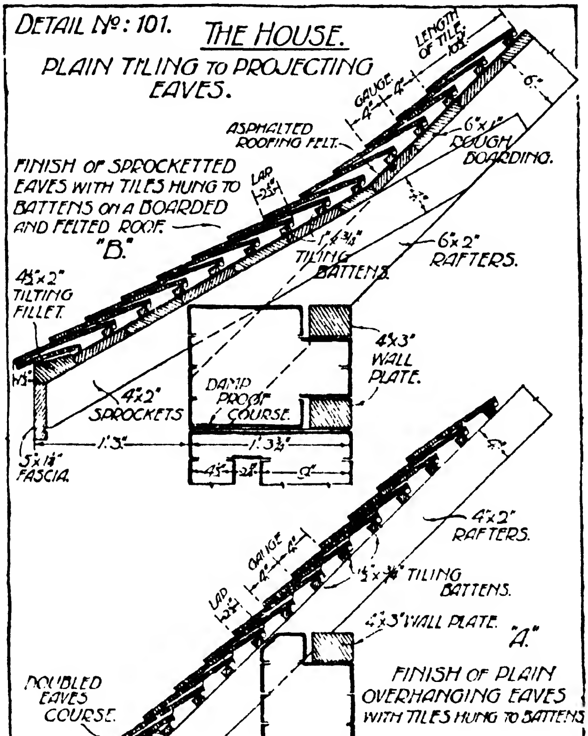
This double eaves course is of shorter tiles, the length being diminished by approximately 4″. These under courses are sometimes cut from full tiles, but this is undesirable owing to the rough edges and the possible waste in cutting; special tiles are obtainable for this purpose, as previously shown.

A bevelled tilting fillet is employed to lift the tail of the course

[1] See Vol. I.

sufficiently and so allow the upper eaves course to bed closely upon it.

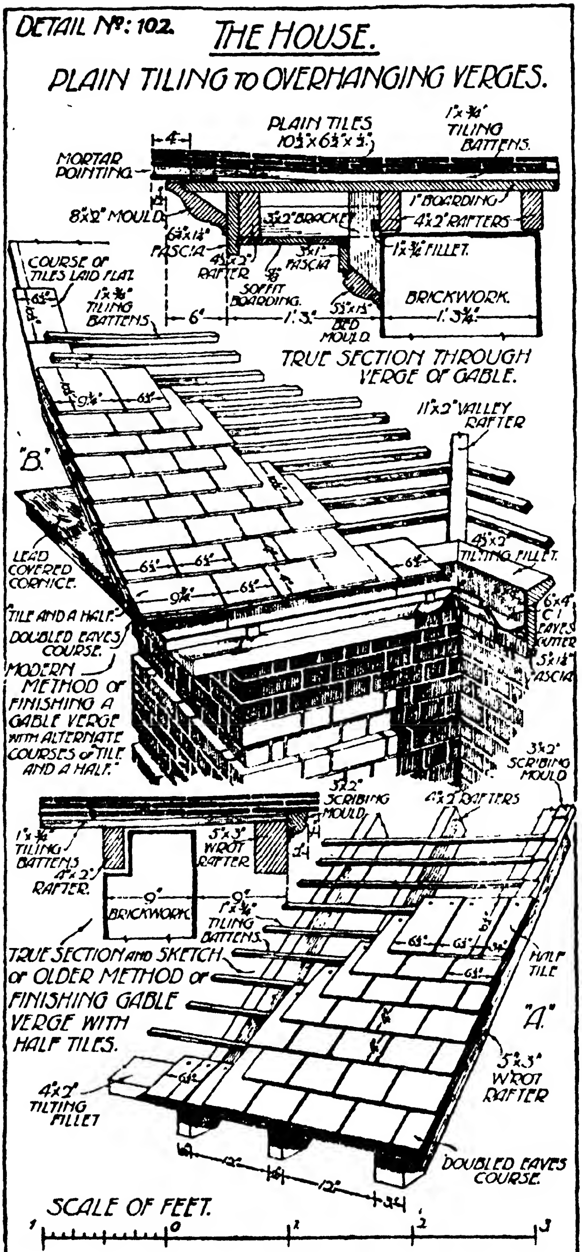
The first full course should be nailed throughout its length, and also every fourth or fifth course succeeding it when nibbed tiles are employed. In long courses it is wise to nail a few intermediate tiles



at uniform distances in every course in addition to the fully nailed courses referred to above.

In the best work for exposed situations all tiles are nailed.

321. Sprocketted eaves of tile roof. The same detail at B shows nibbed tiles hung on battens laid upon close boarding and applied to the sprocketted eaves of the house roof. It should be observed


DETAIL No: 102. THE HOUSE.
PLAIN TILING TO OVERHANGING VERGES.
PLAIN TILES 10½"x6½"x½"
1"x¾" TILING BATTENS.
MORTAR POINTING
8"x2" MOULD
1" BOARDING
4"x2" RAFTERS
1"x¾" FILLET.
BRICKWORK.
SOFFIT BOARDING.
BED MOULD.
TRUE SECTION THROUGH VERGE OF GABLE.
COURSE OF TILES LAID FLAT.
1"x¾" TILING BATTENS
11"x2" VALLEY RAFTER
"B."
LEAD COVERED CORNICE.
"TILE AND A HALF" DOUBLED EAVES COURSE.
MODERN METHOD OF FINISHING A GABLE VERGE WITH ALTERNATE COURSES OF TILE AND A HALF."
3"x2" SCRIBING MOULD
4"x2" RAFTERS
5"x3" WROT RAFTER
4"x2" RAFTER.
BRICKWORK
1"x¾" TILING BATTENS
TRUE SECTION AND SKETCH OF OLDER METHOD OF FINISHING GABLE VERGE WITH HALF TILES.
HALF TILE
"A."
5"x3" WROT RAFTER
4"x2" TILTING FILLET
DOUBLED EAVES COURSE.
SCALE OF FEET.

that the tiles form an easy curve at the angle of junction of sprocket pieces and rafters, due to the change of slope as each row of tiles is bedded after reaching the "break"; this curve continues until the break in the slope is fully bridged.

322. Verges in plain tiles. Verges are the overhanging edges of a roof covering at gables, where the slope of the covering is exposed.

Two methods of finishing a verge are shown in detail No. 102. At A is illustrated the older method of obtaining the side lap of the consecutive courses by inserting a half tile in width to alternate courses at the verge. All the verge tiles and half tiles must be well nailed and should be bedded solid in mortar over the gable wall and projection; in addition, a stout moulding 1½" to 2" thick should be scribed to fit the under surfaces of the verge tiles and to support them at the overhang. Not more than 1" clear projection of the tiles beyond the mould should be permitted in order to reduce to a minimum the liability of the verge tiles to be lifted by the wind.

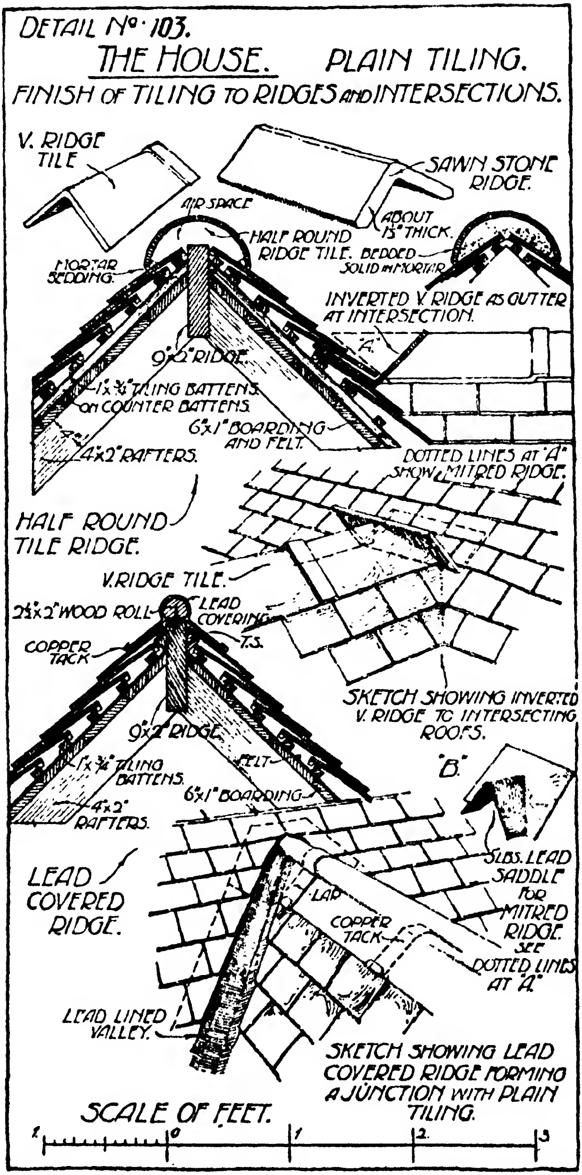
The second and more modern method of finishing a verge is illustrated in the detail at B, where the half tile widths are replaced by special "tile and a half" tiles, which are easily obtainable. The verge is also canted inwards by inserting a packing course of plain tiles, which are laid immediately upon the close boarding at the overhang; the tiling laths are bent upwards to lie upon the packing course and are stopped about 4" from the edges of the tiles. The verge tiles are then laid to the same projection as the packing course and the space between made up solid with cement mortar, which ensures security to the edges where they cannot be nailed owing to the stopped laths.

The inward canted edges of the verge prevent rain-water overflowing the edges and dripping therefrom, unless a very strong wind is blowing.

323. Ridge coverings to plain tiles. Ridges may be covered with plain Λ ridge tiles, 18" long and about ½" thick, having rebated joints; or with half-round tiles about 9" diameter and 18" to 20" long; or, again, with sawn stone ridges 1½" thick; see detail No. 103. Whatever covering is selected it should harmonise with the tiling in colour and not interfere unduly with the outline of the ridge; rebated joints are somewhat objectionable on the latter score and for this reason plain butt joints are often employed and jointed or pointed with good cement or with oil mastic.

The ridge tiles should be bedded in mortar upon the "under ridge tiles" leaving a free air space above the wood ridge.

In very exposed positions the ridge tile may be solidly bedded in mortar and to prevent the mortar coming in contact with the timber the under tiles should be arranged to meet each other at the apex.


DETAIL No. 103.
THE HOUSE. PLAIN TILING.
FINISH OF TILING TO RIDGES AND INTERSECTIONS.
V. RIDGE TILE
SAWN STONE RIDGE.
AIR SPACE
ABOUT 1½" THICK.
HALF ROUND RIDGE TILE. BEDDED SOLID IN MORTAR
MORTAR BEDDING.
INVERTED V RIDGE AS GUTTER AT INTERSECTION.
"A"
9"x2" RIDGE
1"x¾" TILING BATTENS ON COUNTER BATTENS
6"x1" BOARDING AND FELT.
4"x2" RAFTERS.
DOTTED LINES AT "A" SHOW MITRED RIDGE.
HALF ROUND TILE RIDGE.
V.RIDGE TILE.
2½"x2" WOOD ROLL
LEAD COVERING
T.S.
COPPER TACK
SKETCH SHOWING INVERTED V. RIDGE TO INTERSECTING ROOFS.
9"x2" RIDGE.
1"x¾" TILING BATTENS.
FELT
6"x1" BOARDING
4"x2" RAFTERS.
"B"
5LBS. LEAD SADDLE FOR MITRED RIDGE. SEE DOTTED LINES AT "A"
LEAD COVERED RIDGE.
LAP
COPPER TACK
LEAD LINED VALLEY.
SKETCH SHOWING LEAD COVERED RIDGE FORMING A JUNCTION WITH PLAIN TILING.
SCALE OF FEET.
1
0
1
2.
3

324. Lead-covered ridge. Ridges to tiled roofs may be covered with lead as in the case of slated roofs. The tiles are stopped against the ridge, as shown in the same detail, provision for nailing the top course being made by a thicknessing strip (TS) and the wood ridge set to finish level with the tiles.

A wood roll, wider than the ridge, is fixed upon it by double spiked nails and during this operation copper or lead tacks are inserted across the joint at about 3 ft. centres, their function being to clip the lead capping at the lower edges, as shown. The visible association of lead with tiles is not always pleasing, but may be made so by judicious selection of the tiles with regard to colour.

325. Ridge terminations at intersections with roof slopes. In the perspective detail No. 99, it will be seen that the ridge of the front gable is at a lower level than that of the flat, and the ridge thus intersects the main surface of the plain tiling.

This termination may be made watertight by a sheet lead saddle piece, which is used when lead soakers or lead gutters are employed in the valley covering; see detail No. 103 at B. If valley tiles[1] are employed, an inverted ridge tile may be used in the manner shown; a portion of the wood ridge and ridge tile is cut back to obtain a neat fit against the inverted tile and the latter is interleaved between two courses of plain tiles on the main slope, while the opposite wing is bedded solidly in cement mortar against the cut end of the ridge.

A short gutter is thus formed which conducts water from the intersection while the splayed ridge is well shielded and directs water from the joint.

The treatment of hips and valleys together with unusual applications of tiling, are given in Vol. III.

Concrete and Asphalte-Covered Flat Roofs

326. Concrete flat roofs. It is often convenient and economical to use a flat roof in preference to a pitched roof, or the selection may be necessitated by structural conditions such as the provision of natural light to parts of a building where a pitched roof would form an obstruction.

Wood-framed roofs covered with lead have already been referred to in Vol. I, and these are given further attention in a later chapter.

Lead-covered roofs are expensive both in first cost and in maintenance, especially if very exposed or subjected to wear through people moving upon them.

Concrete roofs are economical in first cost and require no maintenance if properly designed and rendered watertight.

[1] See Vol. III.

Such roofs must be designed to carry a load of about 56 lbs. per sq. ft. in addition to their own weight, which ensures resistance to any probable load without undue deflection.

327. Waterproofing of concrete roofs. Concrete, however well made, is not absolutely waterproof. It may be so well proportioned and mixed as to be sufficiently resistant to rain when used in vertical walls, but it cannot be relied upon when used in horizontal layers and continually exposed to rain. Neither can it be dependably covered with any untreated cement floating or mortar covering; slight defects may occur due to air bubbles becoming enclosed; hair-line cracks may form by contraction in the setting process; and faults due to unskilled or careless workmanship are common.

There are two necessary and primary conditions to be fulfilled if a reliable flat roof is to be constructed in concrete, viz.:

(*a*) provide sufficient and accurate falls, not less than 2″ in 10 ft. or 1 vertical in 60 parts horizontal;

(*b*) provide a waterproof covering of mastic asphalte.

Even if these provisions are satisfactory, there are others of sufficient importance to note, including

(*c*) supports which can be relied upon not to settle, since irregular settlement may reduce the efficiency of the falls and gutters;

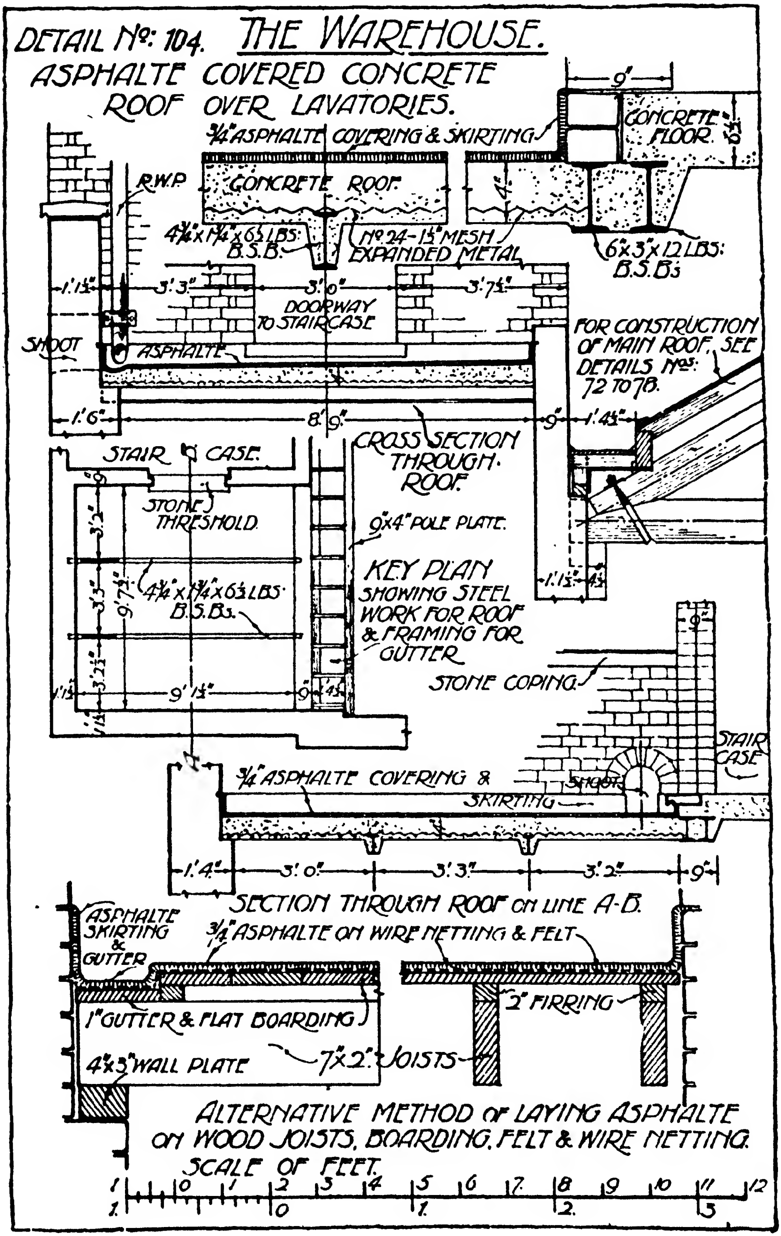
(*d*) if the slabs of concrete between lines of support exceed 3 ft., wire mesh reinforcement should be adopted to distribute the "setting and loading stresses," and thus avoid large cracks forming in the slab, which may be communicated to the covering;

(*e*) adequate gutters and outlets for the discharge of rain-water from the flat.

328. Effects of irregular settlement of supports. Many concrete flats have been rendered inefficient for draining off rain-water through the settlement of light supporting walls or by the use of girders which lacked stiffness. If the falls are slight and yet sufficient under the initial conditions, settlements and deflections may destroy the fall, causing local depressions and retaining water long enough to allow percolation through the slab if the slightest fault exists; hence the advantage of adopting larger falls than may otherwise appear necessary.

329. Flat roof over lavatories of warehouse. Detail No. 104 shows the construction of a flat concrete roof to be used over the lavatories of the warehouse and waterproofed by a layer of asphalte.

The key plan, inset, shows the arrangement for the construction of the flat and its position in relation to the eaves of the main roof. The entrance to the flat is through a doorway from the staircase landing.


DETAIL No: 104. THE WAREHOUSE.
ASPHALTE COVERED CONCRETE ROOF OVER LAVATORIES.
¾" ASPHALTE COVERING & SKIRTING
CONCRETE FLOOR.
CONCRETE ROOF
R.W.P.
4¾" x 1¾" x 6½ LBS. B.S.B.
No 24 - 1½" MESH EXPANDED METAL
6" x 3" x 12 LBS: B.S.Bs
DOORWAY TO STAIRCASE
SHOOT
ASPHALTE
FOR CONSTRUCTION OF MAIN ROOF, SEE DETAILS Nos: 72 TO 78.
CROSS SECTION THROUGH ROOF
STAIR CASE
STONE THRESHOLD
9" x 4" POLE PLATE.
KEY PLAN SHOWING STEEL WORK FOR ROOF & FRAMING FOR GUTTER
4¾" x 1¾" x 6½ LBS. B.S.Bs.
STONE COPING
STAIR CASE
¾" ASPHALTE COVERING & SKIRTING
SHOOT
SECTION THROUGH ROOF ON LINE A-B.
ASPHALTE SKIRTING & GUTTER
¾" ASPHALTE ON WIRE NETTING & FELT
2" FIRRING
1" GUTTER & FLAT BOARDING
4" x 3" WALL PLATE
7" x 2" JOISTS
ALTERNATIVE METHOD OF LAYING ASPHALTE ON WOOD JOISTS, BOARDING, FELT & WIRE NETTING.
SCALE OF FEET.

330. Supports to flat roof over lavatories. The flat is supported by the outer brick walls on two sides, and upon the lower flange of one of the 6″ × 3″ beams at the staircase end, while the fourth side of the concrete slab butts against the parapet wall of the main roof. Intermediate supports to the slab are provided by two 4¾″ × 1¾″ × 6½ lbs. B.S.B.'s at 3′ 3″ centres, and the concrete is laid upon a reinforcement of expanded metal, wire lattice, welded fabric, or other suitable steel mesh laid directly upon the steel joists.

Shuttering to give temporary support to the concrete is placed in position, 1″ of fine concrete laid upon the platform, the reinforcement placed upon it, and the remaining concrete deposited to the required depth.

The effective depth of the slab is thus about 4½″, measured from the centre of the steel to the top of the concrete, while the steel is adequately covered and protected on the soffit.

With fine aggregate and neatly laid shuttering a sufficiently good finish may be obtained without plastering where economy is to be considered. If desired a plaster ceiling may be added, as described in the Chapter on Plastering.

331. Fall of flat and provision of outfall. The fall of the flat would be at least 1½″ across the breadth of 8′ 9″ towards the external wall, along which a 6″ wide drainage channel is formed, gradually increasing in depth to about 2″ at the discharge end where the water passes through a shoot in the outer wall and enters a rain-water head on the vertical down pipe. The shoot opening is arched over, as shown in the detail, section A–B. To prepare for the asphalte coating the concrete is finished to falls and the side gutter formed in it when depositing.

332. Asphalte covering to flat roof. A ¾″ layer of fine-gritted mastic asphalte is laid over the concrete slab, screeded accurately to the fall and continued round the gutter channel; to ensure weather-tightness at the junctions with the parapet walls, a skirting, at least 3″ deep, is carried up each face, trowelled into a joint in the brickwork, raked to a depth of ¾″, and finished with rounded angles, as shown in the larger section.

At the entrance from the staircase doorway the asphalte enters the joint between the plain threshold and the brickwork, as shown in the upper detail, or the edge may be covered by a 9″ × 3″ weathered and throated threshold, having a clear projection of 1½″, as shown in the lower detail.

333. Staircase landing at entrance to asphalted roof. The support provided for the staircase landing, the 9″ staircase wall and the edge of the asphalted roof, is shown in two sections of the same detail,

where two 6″ × 3″ × 12 lbs. B.S.B.'s are employed. The concrete roof slab is contained between the flanges of the beam and the reinforcing steel is continued to the web of the beam; on the opposite side the concrete floor of the stair landing bears upon the top flange but is haunched down to the lower flange to increase the support and to provide covering to the side of the beam.

By this arrangement the joists are adequately protected on their sides, but the soffits are exposed, and these surfaces require painting for their protection.

334. Bituminous coverings to flat roofs. In addition to mastic asphalte, there are numerous preparations of bituminous sheeting suitable for laying upon close boarding or concrete.

On boarding, the sheets are lapped and nailed, the overlaps being in the direction of the fall and jointed with special composition. They are similarly laid upon concrete floated to falls and entirely bedded in some bituminous mastic. For flat roofs in important work they are often laid in several thicknesses and covered with a layer of fine gravel to preserve the surface. To avoid the gravel being washed into gutters a raised curb is provided at the edge, through which the water can percolate.

Vulcanite, Rexilite, Rok, Lion and Anderson's roofing are well-known kinds. There are special and patent methods of laying and treating these coverings peculiar to each kind.

CHAPTER FIFTEEN

EXTERNAL PLUMBERS' WORK

335. Some consideration was given in Vol. I to plumbers' work which occurred in connection with roof flashings, gutters, down pipes and small lead-covered roofs.

The general principles of laying and securing sheet lead were explained and illustrated, and it is only necessary to recall the main points here in regard to sheet lead work, viz.:

(*a*) Allowance must be made for the large expansion and contraction to which lead is subject; this is usually accomplished by permanently fixing lead sheets on two consecutive edges only, leaving the others free to move laterally, but so lapped and jointed as to maintain their general position in the structure.

(*b*) The dimensions of pieces of sheet lead should be such as to allow them, where possible, to be cut from the width of the sheet, the maximum of which is 9 ft.; in any case the pieces must be small enough to facilitate handling and shaping.

Lead-Covered Flat Roofs

336. Lead flat to main roof of house. Detail No. 99 shows the roof to the house which is covered by tiled slopes springing from the eaves all round the building and terminating at the head against a large lead-covered flat 31′ 4″ × 13 ft., through which rises a chimney containing the flues from the hall, kitchen and bedroom fireplaces.

A skylight is also formed upon the flat, raised above its level by a timber frame. For the construction of this flat see Vol. III.

The flat is divided into two main transverse falls by a longitudinal roll at the centre of the width and each portion is divided into parallel sections by similar wood rolls making in all twenty-two bays of sheet lead jointed over the rolls, shown in Vol. I, which ensures freedom for expansion and contraction while preventing the edges from lifting.

337. Curbed edges of flat. The edges of the flat terminate at a curb or break in the roof surface, formed by large timbers which support the joists and common rafters. Three methods of finishing this edge are shown in detail No. 105, viz.:

(*a*) a plain overlap, without nosing;
(*b*) a welted nosing;
(*c*) a wood roll nosing or bottle-nose edge.

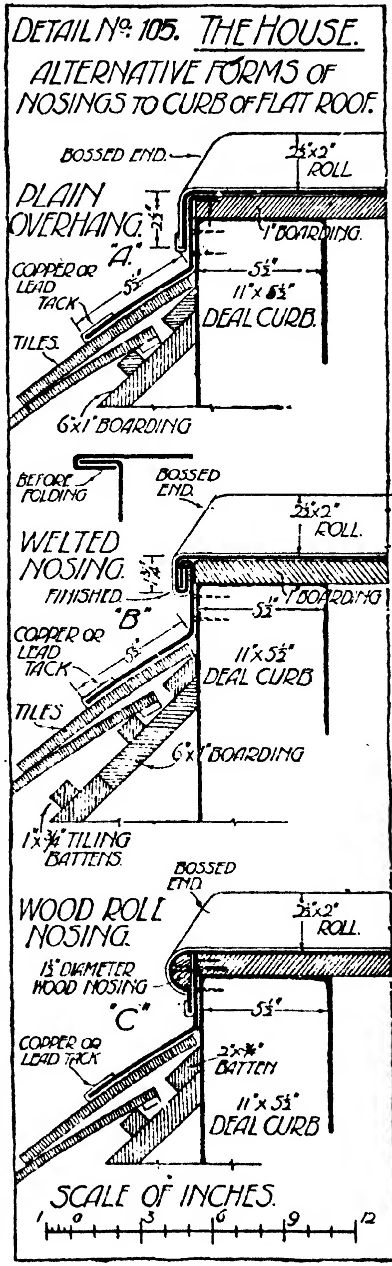
338. Plain overlap at edge of curb. The section at A shows a plain overlap with an under-flashing. Stout lead or copper clips are fixed at intervals of about 2′ 6″ along the face of the curb to receive the edge of the under-flashing which would be in lengths of 6 to 8 ft. and would require two intermediate clips.

The under-flashing is notched level into the boarding, so that the top sheets may be laid and dressed over the edges without obstruction to the flow, and the overlap is sufficiently secured from lifting by the grip of the lead over the ends of the rolls.

339. Welted nosing to curb. The welted nosing is formed by leaving the edges of the under-flashing and cover sheet long enough to fold over, as shown at B. In this case the under-flashing is first laid, with the necessary lead or copper tacks, then the cover sheets placed and dressed over the rolls and bossed down over their bevelled ends. The edges of the sheets are then in the position shown in the sketch to the left, and when folded and beaten flat they present the appearance indicated in section at B.

Welted nosings are very reliable and perfectly resist the lifting tendency of strong winds.

340. Bottle-nose finish to curb. A bottle-nose edge is shown in section at C. Lower clips are first laid to secure the under-flashing and the latter dressed into position and finished with a vertical edge at the level of the boarding.



A second series of clips, in the same lines as the first, is then nailed through the first sheet into the edge of the boarding and a $1\frac{1}{2}''$ diameter semicircular wood nosing secured through the lead into the boarding; the edges of the cover are then dressed over and beyond it to a depth of about $1''$ on the vertical surface and these edges are secured by lapping the clips over them.

A perfectly secure and well-shaped termination is thus obtained and the architectural finish is the best of the three methods.

341. Chimney flashings with soakers. In detail No. 106 is illustrated one method of weather-proofing the junction between the roof-tiling and the vertical side of the chimney and, incidentally, the method of finishing the lead sheet covering at the angle between the chimney and centre parapet wall.

Lead "soakers" are employed at the edges of the raking tiles, and consist of pieces of 5 lbs. lead about $7\frac{1}{2}''$ long bent up $3''$ at right angles, as shown at A, to form an upturn against the wall and having their top ends dressed over the head of the tile to secure them; these soakers should always have a length equal to the gauge + lap + $1''$ for dressing over at the head. When in position the soakers form a continuous angle-covering, lapping $2\frac{1}{2}''$—like the tiles—at each joint on the slope.

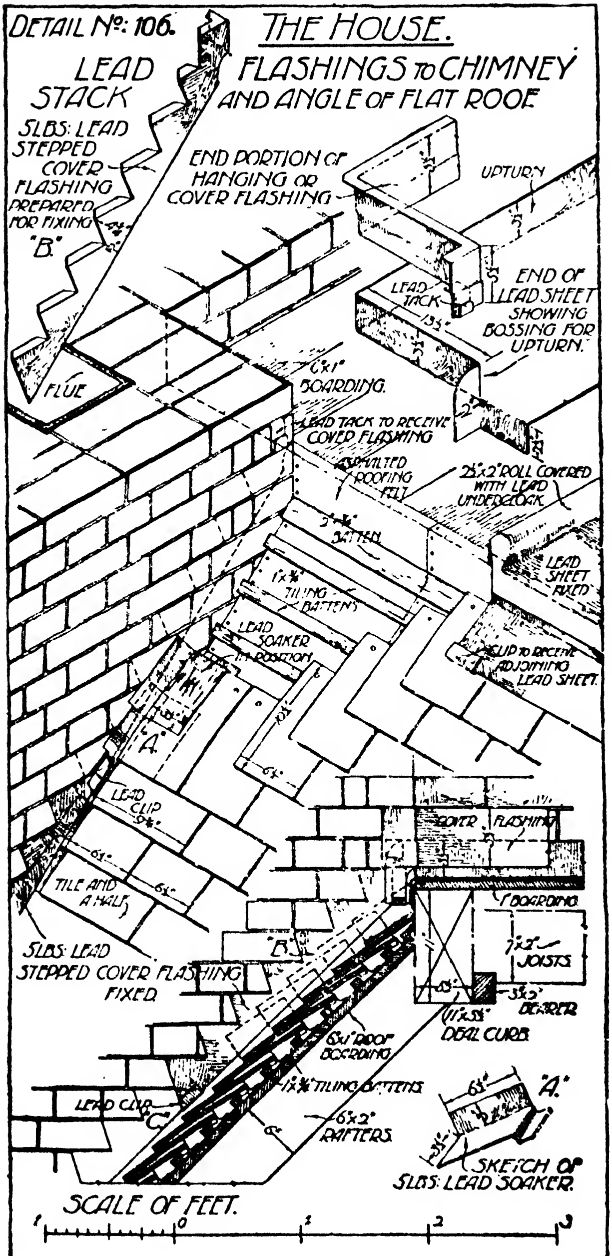
When complete, lengths of stepped flashing are cut, as shown at B, tucked in along the horizontal joints to a depth of $\frac{3}{4}''$, wedged with hard lead or oak wedges, and neatly pointed. Where longitudinal joints occur $2\frac{1}{2}''$ overlap is required and a lead clip employed to secure the exposed edge, as shown at C. The use of soakers with a stepped flashing is a better method than the use of a single stepped flashing, which was illustrated in Vol. I.

The soakers of detail No. 106 overcome the fault which is apparent in the single flashing, viz. the liability to admit drifting snow or rain during a storm under the free edges of the lead upon the roof surface, and also obviate the exposure of flat bands of lead upon the face of the tiles.

The method of finishing the leadwork to the angle of the chimney and parapet is also shown in this detail with the pieces detached. An upturn of $3\frac{1}{2}''$ is given to the cover sheets against the wall and an overlap of $2''$ round the external angle; a hanging or cover flashing $5\frac{1}{2}''$ deep at the exposed part overlaps the upturn by $2''$ and is secured at intervals along the bottom edge by strong lead clips, while the top edge is tucked into a joint, wedged and pointed.

342. Soakers in hip and valley construction. Soakers may be very usefully employed for hips and valleys in slated or tiled coverings, though more suited to slating.

The details of their application are contained in Vol. III.


DETAIL No: 106.
THE HOUSE.
LEAD STACK FLASHINGS TO CHIMNEY AND ANGLE OF FLAT ROOF
5LBS: LEAD STEPPED COVER FLASHING PREPARED FOR FIXING
"B"
END PORTION OF HANGING OR COVER FLASHING
UPTURN
LEAD TACK
END OF LEAD SHEET SHOWING BOSSING FOR UPTURN.
FLUE
6"x1" BOARDING.
LEAD TACK TO RECEIVE COVER FLASHING
ASPHALTED ROOFING FELT
2½"x2" ROLL COVERED WITH LEAD UNDERCLOAK
BATTEN
LEAD SHEET FIXED
1"x¾" TILING BATTENS
LEAD SOAKER IN POSITION
SLIP TO RECEIVE ADJOINING LEAD SHEET.
"A"
LEAD CLIP
TILE AND A HALF
5LBS: LEAD STEPPED COVER FLASHING FIXED
COVER FLASHING
1" BOARDING
7"x2" JOISTS
3"x2" BEARER
11"x5½" DEAL CURB
6"x1" ROOF BOARDING
1"x¾" TILING BATTENS
6"x2" RAFTERS
LEAD CLIP
"C"
SKETCH OF 5LBS: LEAD SOAKER
SCALE OF FEET.
1 0 1 2 3

The units of covering material are mitred at the valley and the pieces of lead are cut to interleave between them and bridge the intersection. The soakers have a length equal to the gauge plus the lap, so that the lap of one soaker over another in the length of the valley is equal to that of the tiles.

Hip and valley soakers have their required form determined by developing or laying out the shapes of the adjacent surfaces which they are required to cover on each side of the mitre line; this is a geometrical problem which specially concerns the plumber.

Flat Roof over Staircase of Warehouse

343. Preparation for lead covering. The carpentry preparation for this lead flat is shown in detail No. 79.

The staircase has a rectangular plan, 18′ 2½″ × 9′ 6″ between walls, which are continued vertically to form a parapet 9″ thick all round the flat.

The fall of the flat is from the centre of the length towards each end, where parallel gutters receive the rain-water and discharge it through lead shoots to rain-water heads. There is one drip across each half of the flat, dividing the fall into lengths of about 4′ 6″, as the whole length is too much for a single fall; similarly, there is a drip across the centre of each length of gutter.

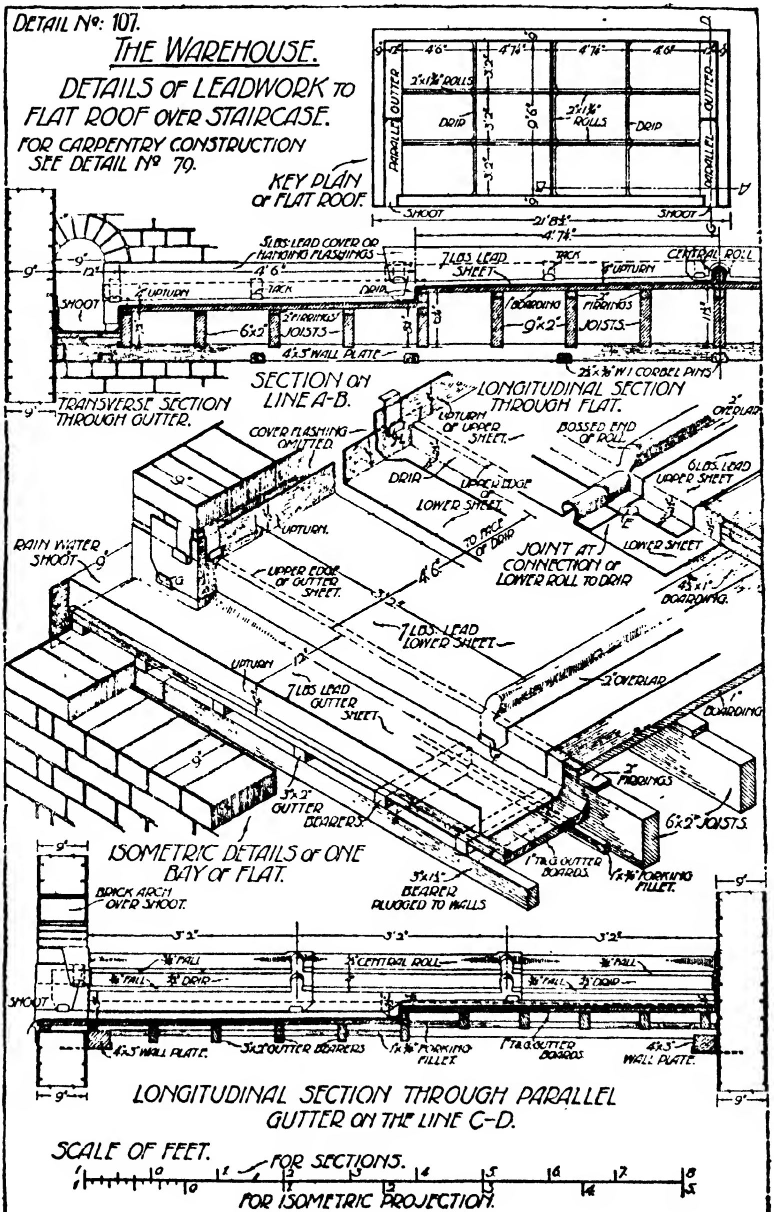
Each unit of the fall is divided into three parts in width by wood jointing rolls at 3′ 2″ centres, so that the individual pieces of sheet lead for the main covering are about 5′ 0″ long × 3′ 9″ wide; 7 lbs. lead is employed for the flat and gutter and 5 lbs. for the cover flashings at the parapet walls.

344. Longitudinal sections of flat and gutter. The general method of laying and jointing the main sheets of the covering is clear from the half longitudinal section of the flat, which is taken along the line AB in the key plan of detail No. 107.

This section shows the gutter, two falls, drip and jointing roll at the crown; the fall is 1 inch in 6 feet.

The variation in depth of gutter and the amount of fall allowed are seen in the lower part of the same detail, which is a longitudinal section through gutter and shoot.

345. Method of laying the lead covering. The leadwork is commenced at the gutter where one piece of lead is used for the lining of the lower level and is extended through the arched opening in the wall, allowed to project and bent downwards to give an easy discharge into the rain-water head. The upturn at the wall is about 4″, and on the other side is sufficient to turn up the vertical face and lap 1″ into the notched ends of the flat boarding, to which it is


DETAIL Nº: 107.
THE WAREHOUSE.
DETAILS OF LEADWORK TO FLAT ROOF OVER STAIRCASE.
FOR CARPENTRY CONSTRUCTION SEE DETAIL Nº 79.
KEY PLAN OF FLAT ROOF.
2"x1¾" ROLLS
DRIP
PARALLEL GUTTER
SHOOT
21'8½"
4'7½"
5LBS. LEAD COVER OR HANGING FLASHINGS
7LBS. LEAD SHEET
TACK
CENTRAL ROLL
UPTURN
DRIP
BOARDING
FIRRINGS
6"x2" JOISTS
9"x2" JOISTS
4"x3" WALL PLATE
2½"x⅜" W.I. CORBEL PINS
TRANSVERSE SECTION THROUGH GUTTER.
SECTION ON LINE A-B.
LONGITUDINAL SECTION THROUGH FLAT.
UPTURN OF UPPER SHEET.
BOSSED END OF ROLL
2" OVERLAP
6LBS. LEAD UPPER SHEET
COVER FLASHING OMITTED.
UPPER EDGE OF LOWER SHEET
TO FACE OF DRIP
JOINT AT CONNECTION OF LOWER ROLL TO DRIP
LOWER SHEET
4½"x1" BOARDING.
RAIN WATER SHOOT
UPPER EDGE OF GUTTER SHEET.
7LBS. LEAD LOWER SHEET
7LBS. LEAD GUTTER SHEET
2" OVERLAP
1" BOARDING
2" FIRRINGS
6"x2" JOISTS
3"x2" GUTTER BEARERS.
1" T.&G. GUTTER BOARDS.
1"x¾" FORKING FILLET.
3"x1½" BEARER PLUGGED TO WALLS
ISOMETRIC DETAILS OF ONE BAY OF FLAT.
BRICK ARCH OVER SHOOT.
⅜" FALL
½" DRIP
3" CENTRAL ROLL
3"x2" GUTTER BEARERS
1"x¾" FORKING FILLET
1" T.&G. GUTTER BOARDS
4"x3" WALL PLATE.
LONGITUDINAL SECTION THROUGH PARALLEL GUTTER ON THE LINE C-D.
SCALE OF FEET.
FOR SECTIONS.
FOR ISOMETRIC PROJECTION.

copper nailed. At the drip the lower piece of lead is similarly treated and the upper one overlapped and continued on the lower level for a length of 2″; at the head of the gutter the lead sheet may be folded into a dog's ear, bossed to a solid angle or cut and soldered to the required rectangular form. Laps and side passings should be about 5″ or 6″ long.

The main covering is then commenced from the edge of the gutter, being turned 3″ within it and dressed 4″ up against the wall and over the jointing rolls.

At the drip the lower sheet is notched to the boarding at the upper level and the upper sheet dressed over it and 2″ on the lower level, as may be seen in the isometric view. The usual roll joint is employed at the crown of the flat, the section being the same as used for the longitudinal rolls.

346. Securing edges of lead sheets. In addition to the grip obtained by dressing over rolls and the stiffness secured by continuity across the face of a drip, it is wise to use lead or copper tacks at vital positions such as passings of sheets, overlaps and facing of prominent surfaces. These may be noted at the points marked E, F, G and H; the point G should be carefully noted, where the covering sheet is dressed round the brick angle at the side of the lead shoot, and also point H, where the upper and lower sheets of the covering pass at the upturn in the angle of the drip.

The formation of the junction at E, where the four sheets are assembled, is also important, the end of the top roll being bevelled and rounded, the lead bossed over it and continued to overlap and encase the head of the lower roll where it abuts against the drip.

347. Cover flashings. On completion of the main covering the walls are flashed all round the upturns with 5 lbs. lead cover flashings, which are shown in the sections but are omitted in the isometric view. These flashings are clipped down by 2″ lead tacks at each joint in the length and also at intermediate positions, the method of securing by tucking into the brick joints being shown in the isometric view at G and H.

The cover flashings continue 4″ round the angle of the shoot opening and all covers are secured by hard lead or oak wedges and pointed in oil mastic.

The minimum overlap of covers over the upturn is 2″.

Leadwork to Skylights and Dormers

348. Skylight in sloping roof of loading shed. When a skylight is to be formed in a tile or slate covered sloping roof, it is most convenient to raise the plane of the skylight several inches above the plane of the roof covering. This enables a weathertight connection

to be made with certainty between the covering and the ground work supporting the light.

The skylight may be of wood or metal[1] and if the former is employed lead flashings are required on all sides of the frame.

Detail No. 108 shows the method of using lead finishings to a wooden skylight suitable for application to the loading shed roof. The light rests upon a curb or frame of wood raised about 5″ above the roof boarding,[2] as shown in section. The method of constructing the curb only affects the plumber in so far as the form of the top edge is varied; it may be left square or tongued to fit a groove in the skylight sash which assists in reducing the draughts inevitably caused by attempting to bed the sash upon a plain lead covered curb.

349. Flashing to base of skylight. The lower flashing is a piece of 5 lbs. lead, 10″ to 12″ wide, dressed and nailed to the top edge of the curb and laid upon the slating to overlap the under-course of slates by 4″; lead tacks are employed at about 2′ 6″ centres to secure the free edge, and the ends are turned 2″ or more round the angles of the curb.

350. Side flashings to skylight. The side flashings may be arranged in two ways to waterproof the junction of slates and curb:

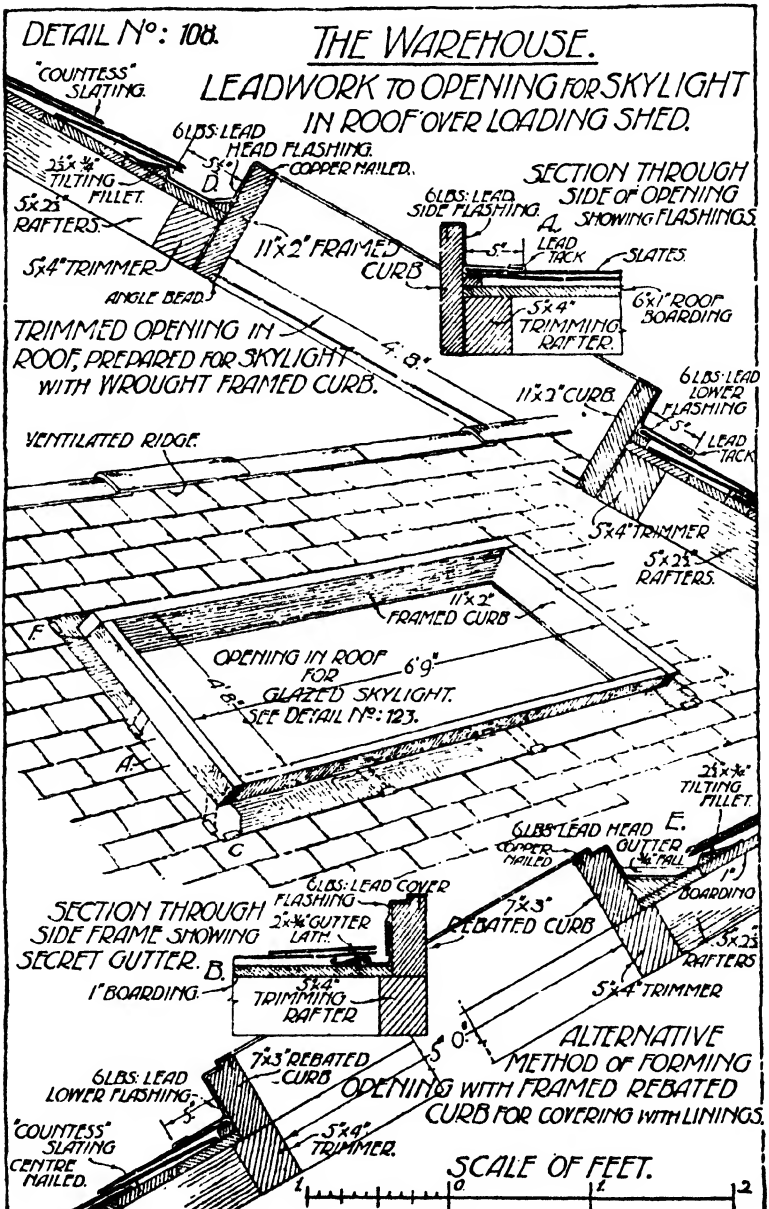
(*a*) A single sheet similar to the lower flashing may be dressed upon the slates and over the edge of the curb, the slates being tilted by a packing lath against the curb to throw rain-water away from the skylight. This method is shown at A in the section and perspective view.

(*b*) A double flashing may be employed and a narrow "side gutter" used, as shown in section at B. In this case the slates are tilted by a bevelled gutter lath and their edges cut within ½″ of the side flashing. In many parts of the country this type of flashing is laid in one piece, but it is not so readily dressed in position, though more economical in material. In any case the lower end of the side flashing is turned round the lower angle of the curb, dressed flat upon the slates below and twice clipped, as shown at C.

351. Head flashing to skylight. The head or back flashing of a skylight invariably forms a gutter to convey the water discharged behind the curb, hence the height of the curb is determined by the form of gutter and its length. Such gutters must have sufficient fall to ensure a rapid discharge and wide skylights therefore need a deeper gutter than narrow ones in order to accommodate the fall.

The section at D shows how the gutter may be formed for a narrow light, the slates being kept 4″ or 5″ clear of the curb and lifted by a tilting fillet to preserve their correct bedding and bonding

[1] See paragraph 200. [2] See paragraph 400.


DETAIL N°: 108.
THE WAREHOUSE.
LEADWORK TO OPENING FOR SKYLIGHT IN ROOF OVER LOADING SHED.
"COUNTESS" SLATING.
6LBS: LEAD HEAD FLASHING.
COPPER NAILED.
2½"x¾" TILTING FILLET.
5"x2½" RAFTERS.
5"x4" TRIMMER
ANGLE BEAD
11"x2" FRAMED CURB
TRIMMED OPENING IN ROOF, PREPARED FOR SKYLIGHT WITH WROUGHT FRAMED CURB.
4' 8"
SECTION THROUGH SIDE OF OPENING SHOWING FLASHINGS.
6LBS: LEAD SIDE FLASHING.
LEAD TACK
SLATES.
5"x4" TRIMMING RAFTER.
6"x1" ROOF BOARDING
11"x2" CURB.
6LBS: LEAD LOWER FLASHING
LEAD TACK
5"x4" TRIMMER
5"x2½" RAFTERS.
VENTILATED RIDGE.
11"x2" FRAMED CURB
OPENING IN ROOF FOR GLAZED SKYLIGHT. SEE DETAIL N°: 123.
6'9"
4'8"
2½"x¾" TILTING FILLET.
6LBS: LEAD HEAD GUTTER
COPPER NAILED
1" BOARDING
5"x2½" RAFTERS
5"x4" TRIMMER
7"x3" REBATED CURB
SECTION THROUGH SIDE FRAME SHOWING SECRET GUTTER.
6LBS: LEAD COVER FLASHING
2"x¾" GUTTER LATH.
1" BOARDING.
5"x4" TRIMMING RAFTER
ALTERNATIVE METHOD OF FORMING OPENING WITH FRAMED REBATED CURB FOR COVERING WITH LININGS.
6LBS: LEAD LOWER FLASHING
"COUNTESS" SLATING CENTRE NAILED.
7"x3" REBATED CURB
5"x4" TRIMMER.
SCALE OF FEET.

with the surrounding slates. For wide skylights and in all first-class work the gutter should be formed, as shown in the section at E, having a tapered triangular fillet falling from the centre to the ends. In longer gutters where the width of the gutter bottom becomes greater than 4″ owing to the rise towards the crown, a 1″ board may be splayed and fitted against curb and roof boarding, leaving a hollow space beneath it.

To ensure sufficient protection of the upper angles of the curb, the side flashings are turned 2″ round them and the head flashing similarly turned down the sides; it is then continued across the full width of the side flashing and clipped at the overlap, as shown at F, or across the full breadth of the side gutter as the case may be.

Lead Coverings to Stone, Brick and Wood Cornices

352. Projecting portions of masonry, brickwork, woodwork, etc., such as large cornices and string courses, may be protected on their upper surfaces by covering with lead, which, in the case of stonework, is much preferable to guarding the joints by saddles worked upon the stone, as illustrated in Vol. I.

The latter method does not prevent all water reaching the joint, but merely gets rid of the excess falling near, which might, by irregularities and deterioration, drain into it; even when the interior of the joint is sound some water often trickles down the face of the work opposite the joint if the mortar is partially destroyed at the drip of the cornice.

Lead coverings will prevent this action and protect the whole of the upper surface.

353. **Lead covering secured with lead dots.** Detail No. 109, at A, shows a common method of covering a stone cornice.

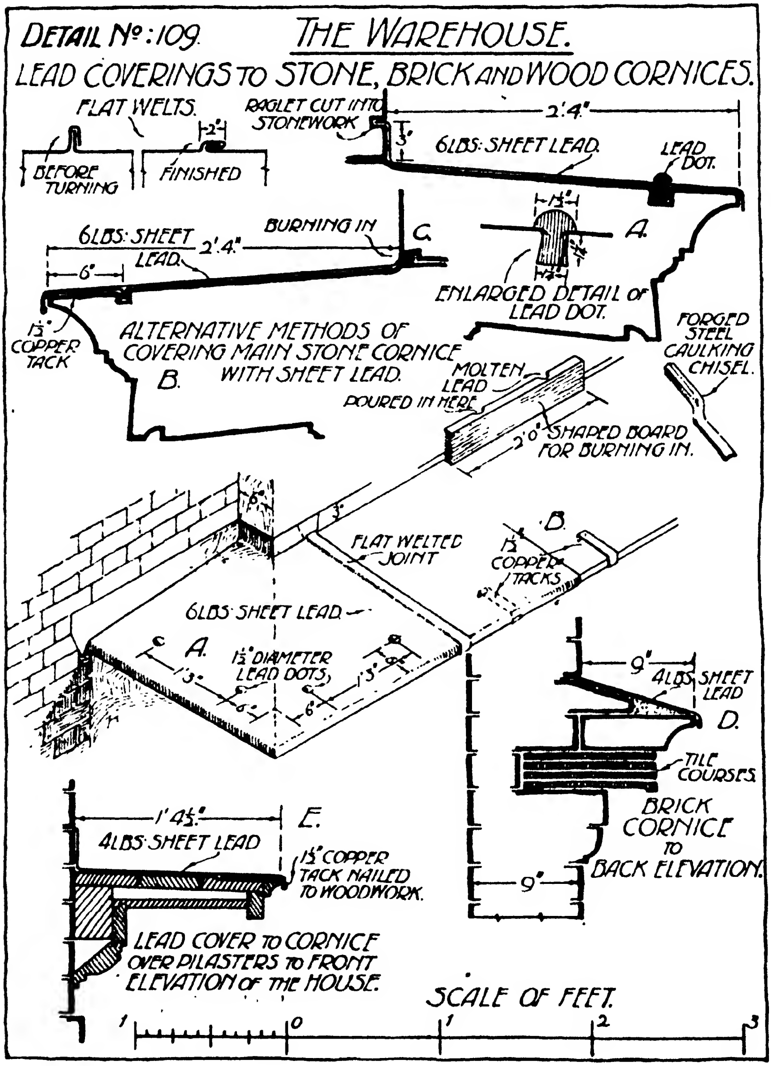
The weathered surface is sheeted by 6 lbs. lead turned down over the front edge and protruding sufficiently below it to form a drip, while the back edge is turned 3″ up the vertical face of the wall or blocking course above and tucked into a "raglet" or narrow groove cut into the masonry, ¾″ deep.

The back edge may be secured by wedging and pointing, though this is more suited to brickwork; a better method for masonry is to "burn in" the edge, as described in paragraph 355.

The front edge is kept from lifting by small plugs of lead run into conical holes drilled in the weathered surface; the lead is poured through a small mould which produces a spherical head overlapping the sheet and is known as a "lead dot".

Lead dots for cornices should be as near the outer edge of the work as its shape and strength will allow, and are usually spaced at 15″ to 18″ centres along the length.

354. Lead covering secured by copper tacks. As an alternative to lead dots, and at the same time to stiffen the sheet and prevent



the down-turn being lifted by the wind, copper tacks about 9" long may be burnt into dovetailed holes cut in the cornice, as shown at B, and bent down flat upon the weathered surface; these tacks

should project in front of the cornice, in this case 2½", and the lead covering ¾" beyond them. The edge of the sheet is folded over to clasp the tacks and the whole dressed down to the vertical position, forming a drip and producing a stiff edge.

Transverse joints in the lengths of lead covering are flat welted.

Expansion and contraction are sufficiently provided for.

It should be noted that lead will not adhere to copper, unless the latter be first tinned, a process not often applied to tacks for cornices. Where tinning is not done, the enclosed ends of the tacks should be deformed to give a hold without depending solely upon adhesion.

355. Burning-in edges of lead sheets. This term is used to denote all modes of securing leadwork, which require molten lead to be run into a recess or raglet. Whenever molten lead comes into contact with a clean surface of metallic lead a portion of this is sufficiently heated and softened to unite firmly with the poured metal; hence, with satisfactory workmanship, a perfect fixing is obtained.

One defect is liable to occur, viz. the poured metal will contract on cooling and may contain cavities due to the inclusion of air, and the metal needs consolidation which is obtained by caulking.

356. Lead covering to cornice secured by burning-in. The method of fixing the upper edge of a lead covering to a stone cornice is shown in detail No. 109 at C. The back edge is turned up a short distance and passed into a raglet cut to a dovetailed section; to secure it, molten lead is poured in by using a shaped board placed against the wall, having pouring holes which conduct the molten metal into the groove. After pouring, the lead is "caulked", that is, consolidated by driving it tightly into the joint along its whole length, for which purpose a caulking tool or chisel is used of the form illustrated in the detail.

357. Lead coverings to brick and wood projections. Examples of the method of covering brick and wood projections are given in the same detail at D and E. In the former a brick cornice is so treated and in the latter the capital of a brick pilaster. The work involved in each case is a simple application of methods previously described.

358. Lead flashings to patent glazing. An example of the type of lead flashings required for patent glazing of roof lights will be found in a previous chapter.

359. Lead covering to hood over tradesmen's entrance. The covering to the hood over the tradesmen's entrance to the house is of 6 lbs. lead falling towards the two sides; see detail No. 113. With such an arrangement the rain is discharged over the edges of

the cornice on each side of the doorway, hence there must be room for direct entrance in front. If side approaches are confined within the projection of the hood small gutters and lead down pipes may be required, or as an alternative the roof may be arranged as detailed for the entrance porch in Vol. I.

The only new feature in this example is the method of securing the upturn of the lead sheet at the transome of the door frame. This upturn is secured by copper nails to the margin of the transome below the groove, which is prepared to receive a tongued oak strip; the latter is fixed by brass screws to the frame, through the turned-up edge of the lead.

Such a method is useful for positions where the lead cannot conveniently be tucked into a groove or a flashing inserted during the construction.

CHAPTER SIXTEEN

JOINERY

Doors

The previous studies of Joinery, contained in Vol. I, dealt with many of the features common to small domestic buildings and workshop premises.

Certain principles of construction were observed and applied. These are further illustrated in the present chapter in their application to the class of joinery considered suitable for a good semi-detached suburban house and also for a town warehouse.

360. Principles governing the construction of joiners' work. The main principles of good joinery construction may be stated as follows:

(*a*) Employ well seasoned and dry material; this avoids changes of form as far as possible and at least limits the changes to comparatively small contractions.

(*b*) Provide for unavoidable small changes of dimension due to further seasoning, variation of temperature and humidity of the atmosphere, by tongued and grooved joints or housings which will allow movement without exposing open joints.

(*c*) Prepare loose framing such as doors and sashes, with a view to retaining their original shape. This calls for careful selection of widths of members, and the adoption of joints which will ensure rigidity.

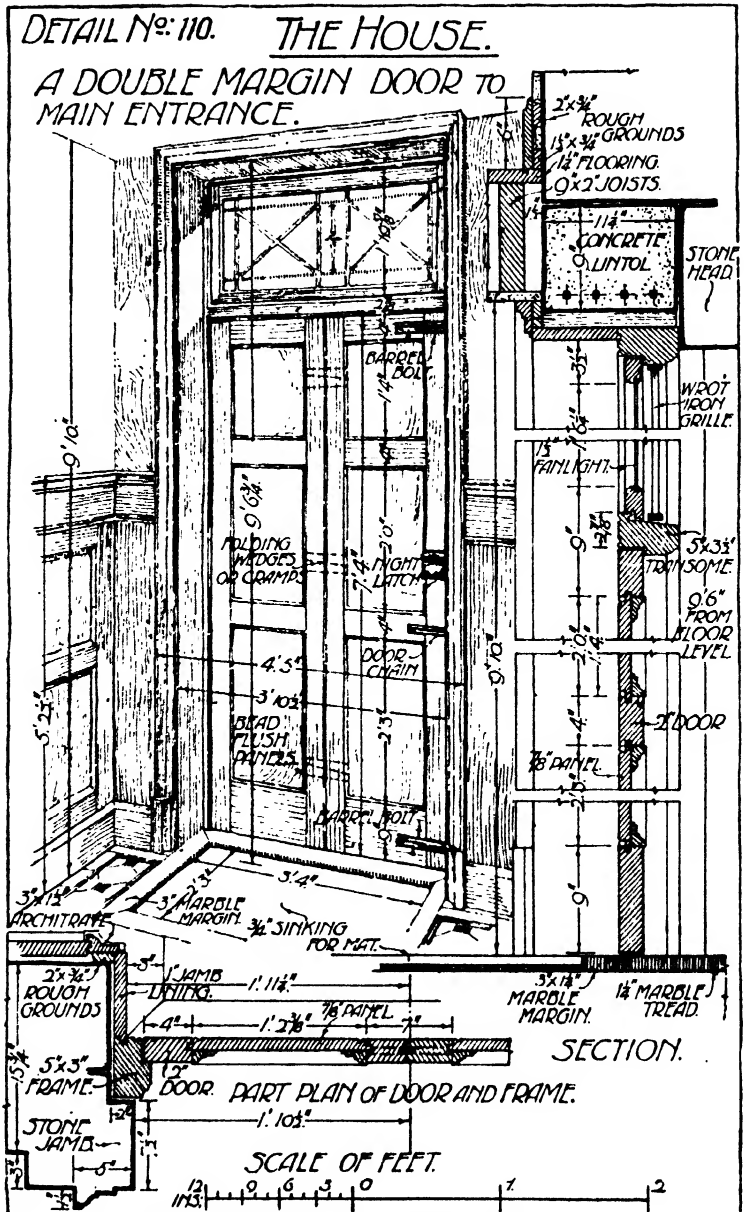
(*d*) Keep tenons narrow, using double ones where expedient; tenons should have a width not exceeding six times their thickness.

(*e*) In thick material, such as door frames, employ double tenons in the thickness, each tenon being within one-sixth of the thickness of the material from the face. This assists in keeping the faces true and holding the shoulders close at the joint.

(*f*) Avoid placing dry, well seasoned timber in a damp atmosphere, *e.g.* fixing joinery before plastering; therefore provide rough grounds for the plasterer where possible, and so allow joinery to be fixed when the plastering is dry.

(*g*) Where plywood is employed see that the edges are guarded and sealed against the entry of moisture. This can only be done by using rebated or grooved framing. Panels adjacent to external walls must be waterproofed on the adjoining face.

Other matters of secondary importance will be referred to when considering individual examples.


DETAIL No: 110.
THE HOUSE.
A DOUBLE MARGIN DOOR TO MAIN ENTRANCE.
2"x¾" ROUGH GROUNDS
1½"x¾" GROUNDS
1¼" FLOORING.
9"x2" JOISTS.
CONCRETE LINTOL
STONE HEAD
BARREL BOLT
WROT IRON GRILLE
FANLIGHT
5"x3½" TRANSOME
9'6" FROM FLOOR LEVEL
FOLDING WEDGES OR CRAMPS
NIGHT LATCH
DOOR CHAIN
BEAD FLUSH PANELS
2" DOOR
⅞" PANEL
BARREL BOLT
3"x1½" ARCHITRAVE
3" MARBLE MARGIN
¾" SINKING FOR MAT
3"x1¼" MARBLE MARGIN
1¼" MARBLE TREAD
SECTION.
1" JAMB LINING
2"x¾" ROUGH GROUNDS
5"x3" FRAME
STONE JAMB
2" DOOR
PART PLAN OF DOOR AND FRAME.
SCALE OF FEET
INS.

Doors, Frames and Finishings

361. Double-margin door and frame. When a doorway is too wide for a well proportioned door of ordinary design to be employed and yet too narrow for two separately hinged doors to fold at the centre, the general appearance and good proportions of the latter may be obtained by using a double-margin door. This consists of two separately framed units jointed together at the centre line of the opening.

The front entrance to the house, Vol. III, provides a suitable application, in which a fanlight is arranged above the door to admit light into the vestibule.

The width of the opening will not allow the ordinary door of standard proportions to be used, in which the height is 4 ft. greater than the width. By making the door in two units, as indicated by the perspective detail No. 110, the apparent height with respect to the width is increased, which greatly improves the appearance.

362. Construction of door frame. The frame consists of $5'' \times 3''$ posts and head and a $5'' \times 3\frac{1}{2}''$ transome. Each member is rebated and weather-grooved for the door or sash, moulded on inner and outer edges, and the posts and head also grooved to receive the jamb linings.

The transome is rebated on the *outside* and weathered on the top surface, so that the bottom rail of the fanlight sash can be rebated over it to render the joint weathertight. This method agrees with the treatment of most window cills at the sash joint (see Windows, Vol. I).

For second year study this door frame might be drawn and detailed without the moulding on the inside rebated angle, thus simplifying the construction.

As the frame is over $4\frac{1}{2}''$ thick double tenons might be employed for all joints. In this case they are $\frac{3}{4}''$ thick, the front tenons being placed $1\frac{1}{8}''$ from the face so as not to interfere with the mitreing of the moulds and the back tenons $\frac{5}{8}''$ from the face, as the moulds on the latter are very shallow.

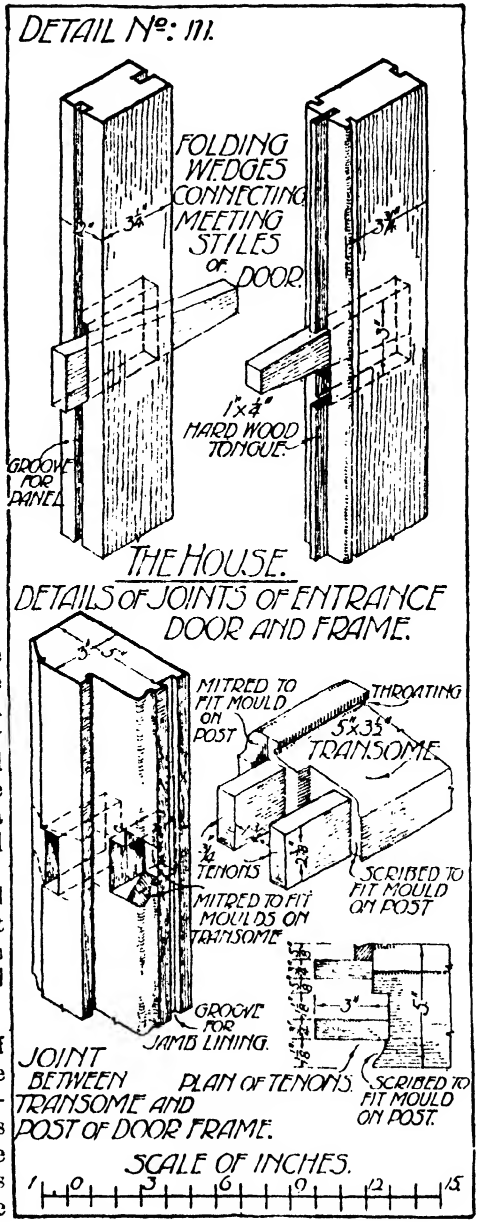
Jointing is shown in the isometric detail No. 111 and the exact positions of the tenons on transome and posts are given in dotted lines in detail No. 112. There are several possible methods of arranging the transome joint, the one adopted being to cut the plan outline of the transome to the section of the post except at the back shoulder, where the undercut form of the mould makes scribing impossible; the shoulder is therefore extended by the width of the mould to allow for mitreing. If the top edges of the tenons were extended to the full width available the bevelled surfaces would

interfere with wedging, they are therefore slightly sunk and made square.

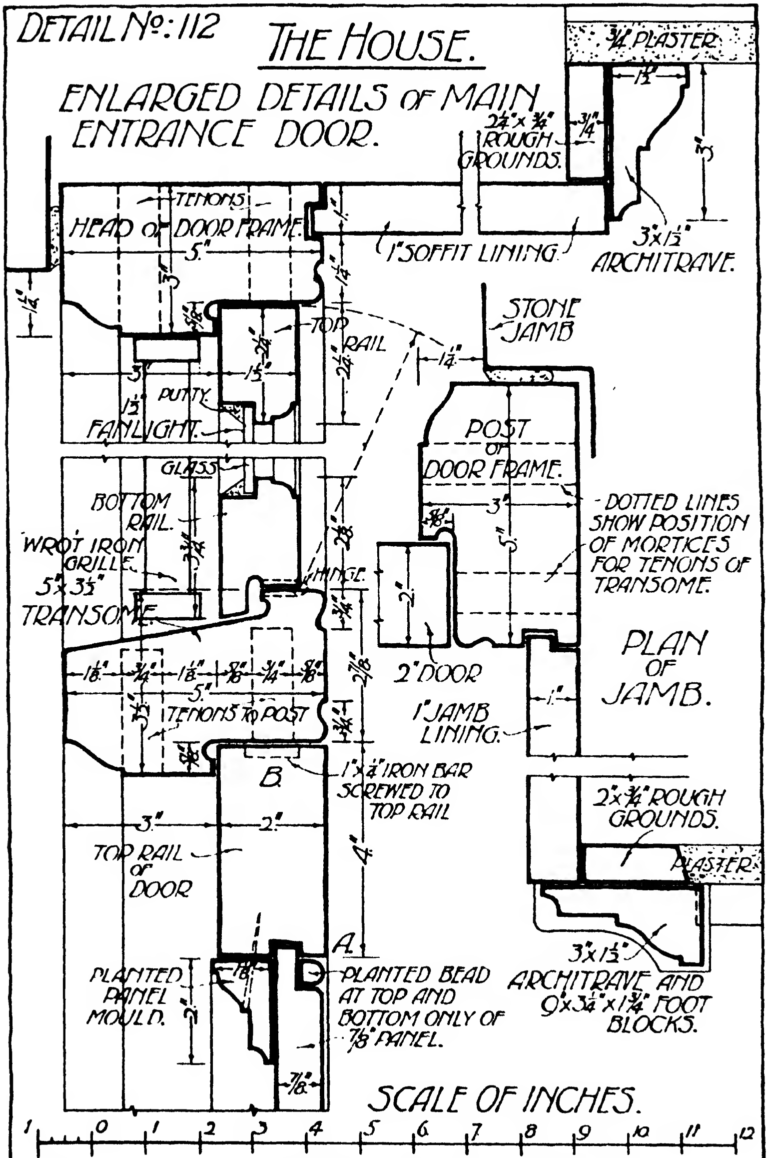
363. Fanlight sash. The fanlight is of oak, $1\frac{1}{2}''$ thick, inset $\frac{1}{2}''$ from the inner face of the frame so that its outer surface is in the same plane as that of the door. It is hinged along its bottom edge, and opens hopper-wise, making the overlapping portion possible at the outside rebate. To ensure that driving rain shall be repelled this joint is doubly weather-grooved, the first check being provided by the groove in the transome and the second by the groove in the sash.

The sash would be jointed by scribed mortice and tenon joints, as given in Vol. I for window sashes in general, and the opening extent of the fanlight controlled by a fanlight opener operated by a cord from the jamb.

A metal grill is placed in front of the fanlight and may be seen through the glazing in detail No. 110.



364. Construction of double-margin door. The door is 2″ thick and is constructed with three panels to each unit. There are four stiles, the outer ones being $4'' \times 2''$ and the


DETAIL No: 112
THE HOUSE.
ENLARGED DETAILS OF MAIN ENTRANCE DOOR.
¾" PLASTER
2¼"x¾" ROUGH GROUNDS.
1" SOFFIT LINING
3"x1½" ARCHITRAVE.
HEAD OF DOOR FRAME
TENONS
TOP RAIL
STONE JAMB
PUTTY
FANLIGHT
GLASS
POST OF DOOR FRAME.
BOTTOM RAIL.
WROT IRON GRILLE.
5"x3½" TRANSOME
HINGE
DOTTED LINES SHOW POSITION OF MORTICES FOR TENONS OF TRANSOME.
PLAN OF JAMB.
2" DOOR
1" JAMB LINING.
TENONS TO POST
1"x¼" IRON BAR SCREWED TO TOP RAIL
2"x¾" ROUGH GROUNDS.
PLASTER
TOP RAIL OF DOOR
PLANTED PANEL MOULD.
PLANTED BEAD AT TOP AND BOTTOM ONLY OF ⅞" PANEL.
3"x1½" ARCHITRAVE AND 9"x3¼"x1¾" FOOT BLOCKS.
SCALE OF INCHES.

centre or jointing stiles 3¼″ and 3¾″ × 2″; this difference in width allows for a ½″ bead to be worked on the wider stile, as shown in detail No. 111, so that when assembled the plain surfaces are of equal width, and practically the same as that shown by the outer stiles when the door is closed, viz. 3⅝″.

The edges of the meeting stiles are grooved to receive 1″ × ¼″ oak tongues, which close the joint and make it weathertight in the event of shrinkage of the stiles.

The centre stiles are prepared for uniting the two parts of the door by morticing in three positions clear of the rail joints, to receive pairs of folding wedges 2½″ to 3″ wide × ⅝″ thick. Before assembling these stiles, the rails are inserted, wedged and squared, the tenon ends slightly cut back and grooved to admit the jointing tongues; folding wedges are then driven and the centre stiles become one unit. Panel grooves are cut to continue across the wedges, panels slipped between the rails and the outer stiles fitted and wedged. All joints must be well glued and the joint wedges made to fit tightest at the points; being an external door the tenons should also have ½″ oak pins inserted ⅝″ from the shoulders so that expansion and contraction is chiefly confined to the outer part of each stile by the combined effect of pins and wedges.

Where large, thick double-margin doors are employed there is a possibility of the tension on the upper end of the centre joint—due to the weight of the door—pulling the folding wedges loose, especially if the material is not thoroughly seasoned. To guard against this a 1″ × ¼″ wrought iron bar is often housed into the top edge across the joint and screwed to the top rails, as shown by dotted lines at B in detail No. 112.

365. Bead flush panels to double-margin door. In this example the panels are ⅞″ thick and almost flush with the framing on the back of the door; they also illustrate what is known as bead flush panels, in which beads are carried round the four edges of each panel, the two vertical ones being stuck, or worked, on the solid, while the horizontal beads are planted separately, as shown at A in detail No. 112, in rebates cut to receive them, and mitred at the ends to the stuck beads. The necessity for this procedure arises from the grain of the wood; a bead cannot be stuck across the grain conveniently nor cleanly as the quirks would cut across each other at the angles unless carved by hand; hence the separate beads.

Where the wood is not well seasoned, the planted bead restricts movement and may result in the splitting of the panel.

366. Bead butt panels. Bead butt panels are preferred by many constructors because of the above mentioned defect. These have

beads only on their edges parallel to the grain, thus terminating by abutting on the framing at the ends.

Both bead flush and bead butt panels are generally made practically flush with the face of the framing; they should, however, be sunk at least $\frac{1}{16}''$ below to avoid interference with finishing the face of the door.

367. Bolection or risen mouldings. Unrebated bolection moulds, often called "risen" moulds, are planted round the panels on the outside of the entrance door, These are $2'' \times 1\frac{1}{8}''$ in cross section, project $\frac{1}{8}''$ in front of the framing and the pattern is such as to provide a sturdy inner edge; the moulds are nailed to the framing, and not through the edges of the panels.

368. Finishings to main entrance doorway of house. The internal finishings to this doorway consist of $1''$ jamb and soffit linings, which are tongued to the door frame and nailed at the outer edge to $\frac{3}{4}''$ rough grounds; the latter are secured to wood plugs at intervals of $2'\ 6''$ in the horizontal joints of the jambs and to $2'' \times 1\frac{1}{4}''$ backings beneath the concrete lintol. These backings are driven tightly into the space above the door frame.

After the plastering is finished flush with the grounds, $3'' \times 1\frac{1}{2}''$ architraves are mitred round; at the floor these spring from $9'' \times 3\frac{1}{4}'' \times 1\frac{3}{4}''$ moulded foot blocks, as shown in the plan of detail No. 112. These foot blocks are wider and thicker than the architrave, with a different and usually plainer mould which roughly follows parallel to the architrave section but omitting the fillets and finer mouldings. Its function is to give a distinctive supporting feature and it should also be high enough and sufficiently thick to admit of the skirting being housed into it.

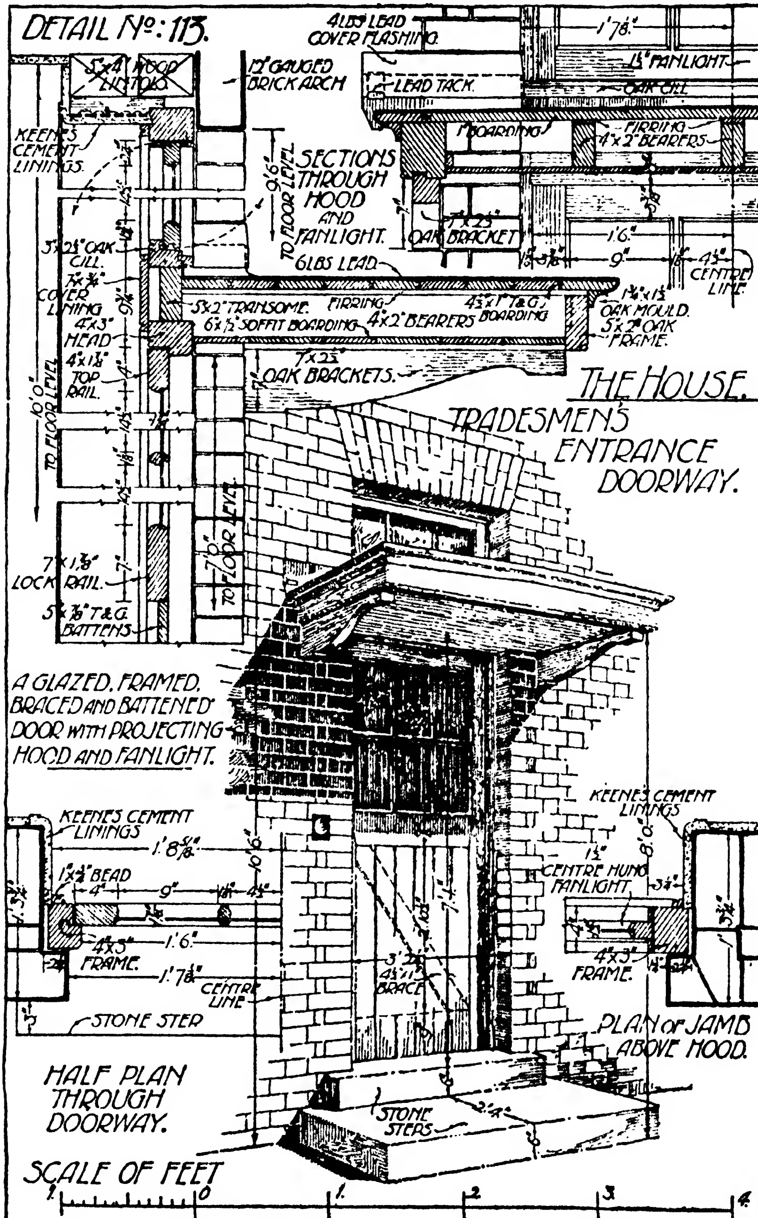
In some cases the foot block is fixed separately, but in important work it is much more satisfactory to joint the block to the moulding by one of the methods shown in Vol. III.

The terms plinth block, skirting block, architrave block and foot block are all applied to the same feature in different districts.

Glazed or Sash Doors

369. Tradesmen's entrance doorway at side of house. This doorway is provided with a glazed door and fanlight and the entrance is sheltered by a cantilever hood projecting about $2'\ 9''$ from the wall and $5'\ 4''$ in width, placed at the transome level. The hood is supported by timber cantilevers built into the wall, or cut and wedged therein, on each side of the doorway; see detail No. 113.

The hood is covered with sheet lead supported on boarding carried by firred joists, these latter being hidden by a match-boarded soffit.


DETAIL No: 113.
THE HOUSE.
TRADESMEN'S ENTRANCE DOORWAY.
SECTIONS THROUGH HOOD AND FANLIGHT.
A GLAZED, FRAMED, BRACED AND BATTENED DOOR WITH PROJECTING HOOD AND FANLIGHT.
HALF PLAN THROUGH DOORWAY.
PLAN OF JAMB ABOVE HOOD.
SCALE OF FEET
4LBS LEAD COVER FLASHING
1½" GAUGED BRICK ARCH
LEAD TACK
1½" FANLIGHT
OAK CILL
1" BOARDING
FIRRING
4"x2" BEARERS
7"x2½" OAK BRACKET
6LBS LEAD
5"x2" TRANSOME
6"x½" SOFFIT BOARDING
4"x2" BEARERS
4½"x1" T&G BOARDING
1¾"x1½" OAK MOULD.
5"x2" OAK FRAME.
7"x2½" OAK BRACKETS.
KEENE'S CEMENT LININGS.
5"x2½" OAK CILL.
COVER LINING
4"x3" HEAD
4"x1⅞" TOP RAIL.
7"x1⅞" LOCK RAIL.
5"x⅞" T&G. BATTENS.
10'0" TO FLOOR LEVEL
9'6" TO FLOOR LEVEL
7'0" TO FLOOR LEVEL
KEENE'S CEMENT LININGS
1½"x¾" BEAD
4"x3" FRAME.
CENTRE LINE
STONE STEP
1½" CENTRE HUNG FANLIGHT
4"x3" FRAME.
4½"x1" BRACE
STONE STEPS
1'6"
1'7⅜"
1'8⅝"
9"
4½"
1'7⅜"
1'6"
3'2½"
7'1"
10'6"
8'0"
0
1.
2
3
4

The fanlight is a pivoted sash about $18\frac{1}{2}''$ deep constructed in the manner described for pivoted sashes in general and illustrated in detail No. 120.

370. Door frame to tradesmen's entrance. The frame is composed of $4'' \times 3''$ posts, door head and fanlight head, and a $3'' \times 2\frac{1}{2}''$ oak fanlight cill.

The posts are continuous and are rebated, rounded at the front edge and beaded on the rebated edge up to the height of the door where they are jointed to a head of similar section. Above this level the posts are perfectly plain and square edged, and similar in section to the fanlight head, thus providing for the guard beads of the pivoted sash to be fixed and cut as required to allow rotation.

The sash cill is $5''$ above the door head and the space between the two members is closed by a $5'' \times 2''$ transome blocking which is stub-tenoned to the posts; to fix the edge of the leadwork to the flat roof, an oak fillet $1\frac{1}{2}''$ deep $\times$ $1\frac{1}{4}''$ thick is tongued into the front edge of the cill and screwed in position after the lead is placed.

To cover the joints between the head and the fanlight cill at the transome level a $7'' \times \frac{3}{4}''$ double beaded cover lining is used, and cut to mitre with $1'' \times \frac{3}{4}''$ marginal beads at the junction between the frame and the plaster linings of the jambs.

371. Construction of sash door. A door which is partially glazed is often called a sash door. The example included here consists of a combination of a framed and braced lower half, and a moulded and rebated sash construction in the upper half.

Two stiles, out of $4\frac{1}{2}'' \times 2''$ stuff, are reduced at the height of the lock rail to a width of $4''$. The lower part is grooved to receive the tongued edges of the filling battens and the bottom rail jointed into it by bare-faced tenons, as illustrated in Vol. I.

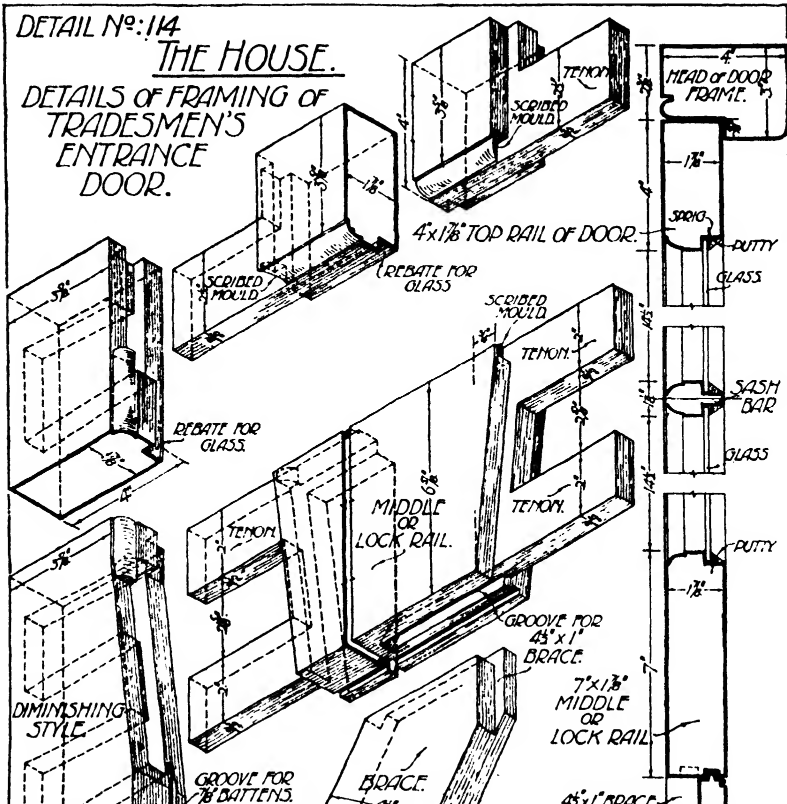
All the joints above the lock rail are made like those of a sash and are shown in detail No. 114. Reference may also be made to Vol. I for joints at the intersection of the sash bars.

The lock rail joint requires special notice. Owing to the change of form in the framing the shoulder needs to be extended on the top edge to the depth of the mould, so that it may be mitred at the junction. From the outer angle of the mitre the shoulder is inclined to the point where the square edges meet on the under side.

The tapered appearance of the stile—though in this case slight owing to the small reduction of width at the sash portion—has caused the term gun-stock or diminished stile to be applied.

The joints between lock rail and stile, top rail and stile, and brace to lock rail are shown in the detail; the use of the scribed joint between the moulds and the overlap provided for cover in view of possible shrinkage should be noted.

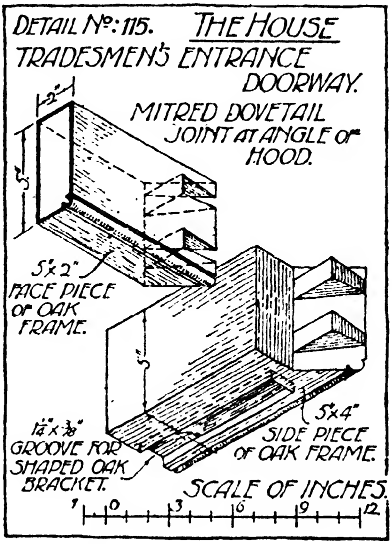
The sash bars would be in short vertical lengths, tenoned between the continuous horizontal members, which enables the top rail to be wedged and forced downwards to close the joints.



372. **Construction of hood to tradesmen's entrance.** The hood is shown in perspective at detail No. 113. It consists of a framed platform, the main members of which are 5" × 4" oak sides, inserted to a depth of 9" within the wall and further supported by 7" × 2½" shaped oak brackets which also enter the wall. Pockets for the insertion of these members are formed during the erection of the

brickwork and they are pinned tightly by wedging from the top with oak wedges and the joints pointed on completion.

The front rail of the frame is also of oak, 5″ × 2″, and of corresponding section to the sides, the two members being mitre dovetailed at the angle, as shown in detail No. 115; the mitre is necessary to continue the angle bead and the thicker piece is rebated to reduce the mitred portions to equal widths. This joint will expose the dovetails partially to view which is the preferable method, but if desired to hide the joint the lower dovetail may be cut ½″ back and the mortice stopped short of the face. The upper dovetail is covered by a cavetto mould, as seen in the section.



The joint between the side frame and the shaped brackets may be housed, or tongued as shown.

The flat roof consists of 4″ × 2″ joists notched into the front frame and over the door head and the fall is obtained by firrings of varying thickness upon the joists; 1″ tongued and grooved boards are laid parallel to the fall, in two lengths, with a joint at the centre. The edge board is "thumb-moulded", this section being returned at the sides by similar moulded oak boards 4½″ wide and tongued to the ends of the covering boards; this tongued joint must be closely fitted to maintain an unbroken surface, otherwise it would be better to continue the roof boarding to the edge and to work the mould across the end of the boards.

The soffit is formed of ½″ match-boarding nailed intermediately to the joists and at the ends to 1″ × ¾″ deal strips fixed to the frame.

For description of lead covering see paragraph 359.

373. Further support to hoods over doorways. Where a hood is desired to be large and heavy in design, or where the wall is such that the cantilevers may only enter to a depth of 4½″, the tendency to withdraw due to the overhanging weight may be relieved by ornamental tension rods inclined at 30° to 45° to the horizontal, secured to the wall and to the top of the frame at about two-thirds of its projection.

Sliding Doors

374. Purpose of sliding doors. Where it is inconvenient to have doors swinging outwards upon hinges and thus traversing considerable space which must be kept clear for the movement, or where doors are very heavy and difficult to hinge in an economical way, it may be found convenient to provide doors moving horizontally. Heavy doors require to be mounted on rollers which may either move on a floor track or be suspended above the door. The latter are easier to apply and more commonly used as the bottom edge of the door only needs guidance to prevent side movement out of the vertical plane.

375. Common method of hanging. Simple iron brackets enclosing large grooved pulleys will serve the purpose as hangers, the bracket being of flat bar iron bent to contain the pulleys which are mounted on bolts, one side of the bar being continued down the face of the door and bolted thereto. These fittings soon get rusty and often become unsatisfactory because they develop too much friction on the bearings and require an appreciable effort to move the door. If used the pulleys should be of chilled metal mounted on hard steel bolts and the track should be of channel section, preferably in heavy cast iron, with one deep flange for bolting to the wall or lintol and a shallow flange with a rounded top edge, in which the rollers travel.

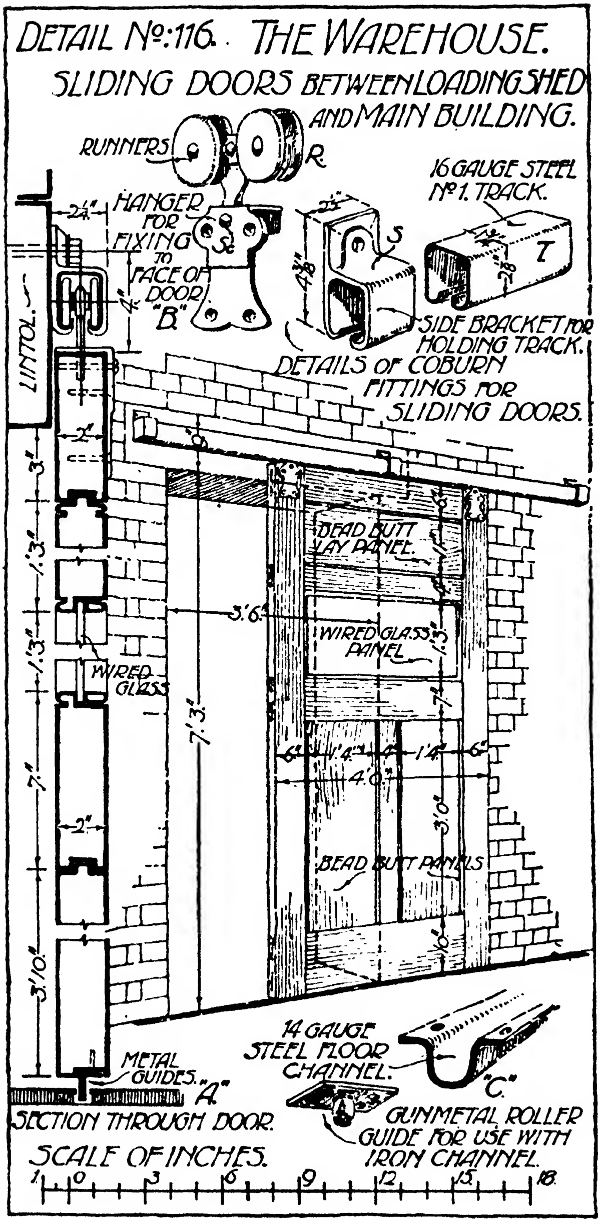
In external work the upper part of the door, along with the track and hanger, should be guarded to keep rain from falling upon them.

376. Special hangers with roller-bearing pulleys. To overcome the faults common to the pulley with a plain spindle bearing, special fittings have been devised for suspended sliding doors of which the Coburn standard set are a good example.

In this system there are tracks, track suspenders, suspension brackets and rollers, floor channels and floor guides, all of which are shown in detail No. 116.

The door is suspended by two malleable iron brackets, B, which are screwed or bolted to the face of the door, preferably to the stiles. To these are fixed two adjustable sets of carriage runners, *R*, four in each set, mounted on ball bearings which, in their turn, receive support from a steel track, *T*, of double J form into which the carriage may freely pass endwise. The four wheels, spaced as shown, give a well balanced suspension with perfectly free traverse along the track and little tendency to side disturbance as in the case of single pulleys.

The track is suspended from special steel sleeves, *S*, made in two


DETAIL Nº:116. THE WAREHOUSE.
SLIDING DOORS BETWEEN LOADING SHED AND MAIN BUILDING.
RUNNERS
R
16 GAUGE STEEL Nº 1. TRACK.
HANGER FOR FIXING TO FACE OF DOOR "B"
S
T
SIDE BRACKET FOR HOLDING TRACK.
DETAILS OF COBURN FITTINGS FOR SLIDING DOORS.
LINTOL.
BEAD BUTT LAY PANEL.
WIRED GLASS PANEL
WIRED GLASS
BEAD BUTT PANELS
14 GAUGE STEEL FLOOR CHANNEL.
"C"
METAL GUIDES. "A"
SECTION THROUGH DOOR.
GUNMETAL ROLLER GUIDE FOR USE WITH IRON CHANNEL.
SCALE OF INCHES.
1 0 3 6 9 12 15 18

forms, viz. end stops, each having one side closed in pairs, and intermediate supports which may be placed anywhere in the length of the track.

The suspension rod, between the carriage and hanging bracket, may be adjusted for vertical hanging by the screw *Sc*, which passes through the foot of the bar. By traversing, the screw moves the suspension rod back or forward until, when the hanger is in the vertical plane containing the centre of gravity of the door, it will hang vertically.

Some of these suspenders and brackets are made with vertical adjustment so that the door may be raised or lowered to the desired position.

To prevent side pressure from moving the door out of its working position without affecting its traverse, two methods are shown at the bottom of the detail. In the section marked A, a groove is formed in the flooring having its edges stripped with $\frac{1}{4}''$ steel plates $\frac{1}{2}''$ apart; a $1\frac{1}{4}'' \times \frac{1}{4}''$ equal steel angle is housed and screwed to the bottom edge of the door and slides in the groove. This method is effective so long as the guide is kept clear of rubbish, but the form makes it difficult to clear if accumulation occurs.

A better method, which admits of easy clearance, is to use the floor channel marked C, which is of U section with two flanges for fixing purposes. Gun-metal roller guides mounted vertically on back plates and screwed to the base of the door travel freely in the channel; a guide roller is separately shown.

377. Internal doors from loading shed to ground floor of warehouse. The doorways opening into the several floors of the warehouse from the main staircase are conveniently fitted internally with sliding doors and these are arranged as shown in the detail. The door is of 2″ hardwood with solid panels, the two lower ones are ordinary bead butt panels with beads on their vertical edges while the top one has the grain lengthwise across the width and the beads horizontal; such an arrangement is termed a "lay" panel.

The middle panel is glazed with thick wired glass,[1] so that it would withstand considerable heat without falling to pieces, though it might crack in the process.

Doors of hardwood, 2″ solid thickness, are accepted as being moderately fire-resisting and wired glass is similarly accepted.

378. Fire-resisting doors. Better fire-resisting doors are made of wood framing faced all round with metal plates and packed solid between the framing with asbestos or silicate cotton.

Many doors are made of steel plate $\frac{1}{4}''$ to $\frac{3}{8}''$ thick, but while these

[1] See Chapter on Materials.

resist fire for a time they lose their shape by warping due to the irregular application of heat during a conflagration, and so allow flames to pass round their edges.

Louvre Panelled Doors

Doors for special purposes are occasionally constructed with their lower portions framed to allow the free passage of air currents, while maintaining sufficient privacy of an apartment when the door is closed.

379. Doors to W.C. enclosures. The most common application is found in doors to sanitary conveniences, such as W.C. compartments in public buildings, workshops, schools, etc.

The method is good, provided that the compartments are enclosed and divided by open topped partitions so that the air can pass through the open framing into the enclosures and rise freely, being dispersed by the fresh air currents from open windows.

Such arrangements are only feasible and sanitary when the room containing the W.C. compartments is isolated from the rest of the building, and by separate ventilation directly communicating with the atmosphere through external walls; one side of the room *at least* should be an external wall.

380. Louvred panels. A louvre is an inclined board set in a containing frame and if used in series so that the upper back edge of any louvre is above the lower front edge of the next higher louvre, the line of horizontal vision is obstructed, hence, if louvres are employed below the level of the eye, they are effective for the purpose in view.

In thin frames a large number of louvres would be required and these should be set at a slope of 45° or more to the horizontal to be both effective and economical.

For ventilating purposes similar glass louvres are sometimes employed to windows of outdoor sanitary conveniences, the glass selected being thick rolled plate or other semi-obscure glazing.

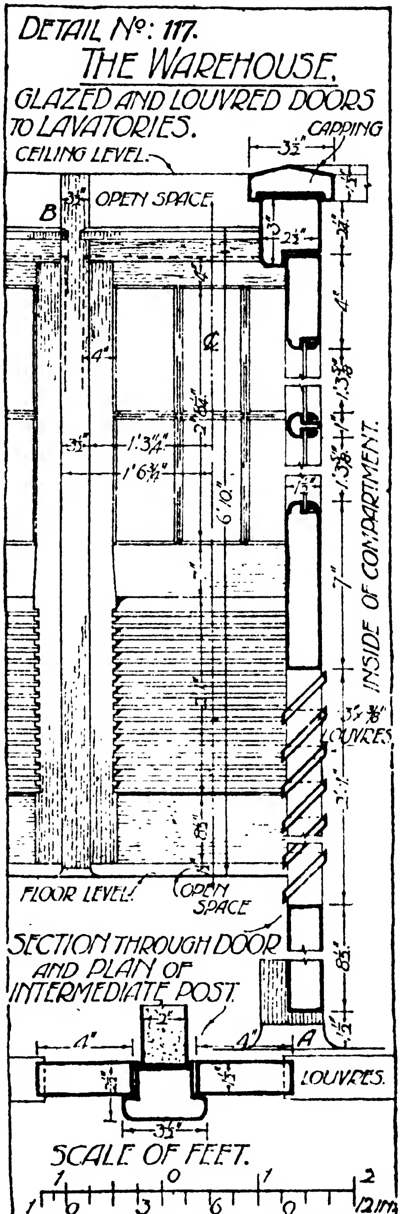
381. Door framing and partitions to W.C.'s of warehouse. The partitions are required to divide and enclose two or more compartments within the lavatories of the warehouse; partition bricks, blocks or slabs may be employed for the purpose, as shown in details Nos. 87 to 91, with door and angle posts rebated for the doors and grooved to enclose the edge of the slabs, as shown in detail No. 117. These posts are $2\frac{1}{2}''$ thick and $3\frac{1}{2}''$ or $4''$ wide at angles and divisions and $2''$ wide at the junction with the main partition across the landing. They are fixed by $\frac{1}{2}''$ dowels and plates to ceiling and floor and at the lower end are kept above the terrazzo floor[1]

[1] See Chapter on Materials.

by raised stools marked A. Heads, 3″ × 2½″, are framed between the posts and 3½″ × 1½″ saddleback cappings are grooved to enclose them and overhang equally on each side. The ends are stopped and returned, as shown at B.

The elevation shows a portion of the lavatory screen with the post continued to the ceiling which is 7′ 4½″ clear above the floor.

The partitions might also be carried to the ceiling if a space is left over the door as shown, though it would be preferable from sanitary considerations to keep the secondary partitions at the level of the door head and provide a wooden capping to terminate them.



382. Glazed and louvred doors to W.C. enclosures. The doors provided are hung with a clearance of 1½″ above the floor. As the compartments require light to be admitted through the doors the upper portion is glazed with obscured glass in six panes divided by 1″ moulded sash bars and secured by ovolo glazing moulds.

The lower panel is filled with 3″ × ⅜″ hardwood louvres, pitched at 45°, notched in ⅜″ deep at the ends, and projecting a little on each face of the door. The projection is a device for obtaining more cover between consecutive louvres in thin frames; 2″ frames often have ½″ louvres finished off level on both faces of the frame.

The joints in frames and doors are similar to those used in earlier details. Mitres would be necessary at the junctions of rounded angles in the frame, unless these were carved in the solid, which is often done for small rounds and chamfers.

383. Setting out louvre frames. The most convenient method of setting out louvre frames is to commence at the base of the section with the lower louvre overlapping the bottom rail or cill as desired; then repeat the gauge until approximately the desired height of the lock rail of the frame is reached.

Attempts to set out the louvres to an exactly preconceived height of panel are wasteful of time and quite unnecessary.

Wardrobe Cupboard Doors and Frames

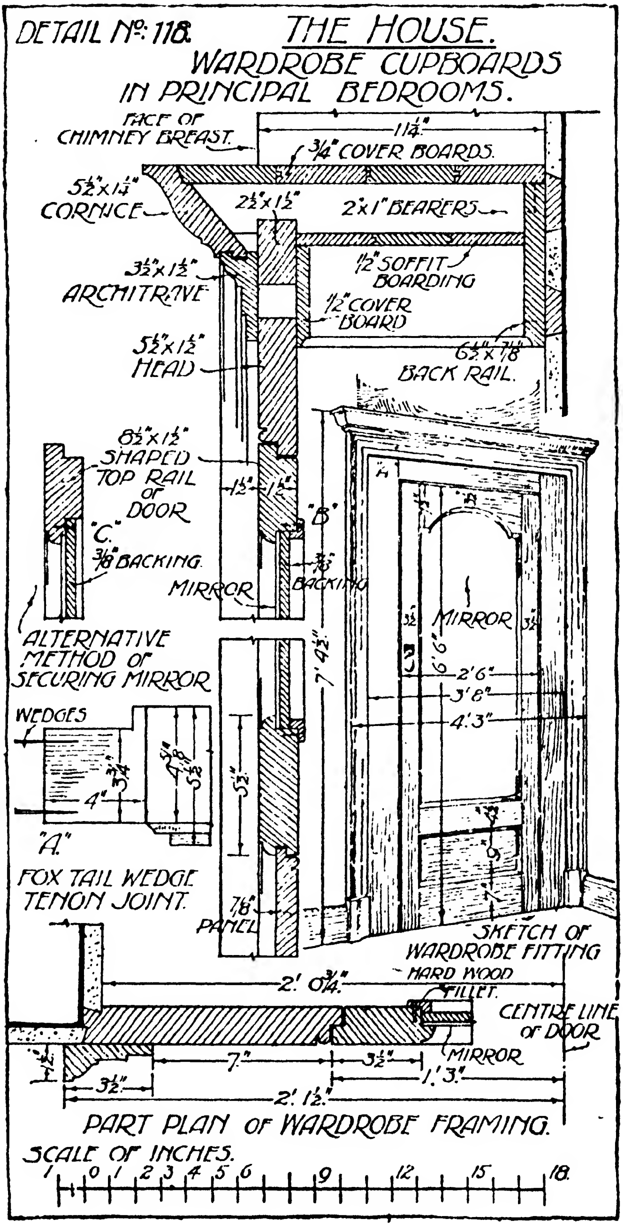
Detail No. 118 shows the design and construction adopted for the wardrobe cupboards which are intended to be fitted into recesses in the principal bedrooms of the house.

The recess dealt with is 4′ 3″ wide × 11¼″ deep, and is enclosed to form a cupboard 7′ 4½″ high to the top of the cornice, with a single door 6′ 6″ × 2′ 6″ having a large mirror in the upper panel. As an alternative the cupboard might be taken to the ceiling to avoid the collection of dust which cannot be avoided on the top of the shorter cupboard.

384. Cupboard frame and enclosure. The enclosure is formed by a 1½″ cupboard frame fitted across the front of the recess and placed flush with the plaster of the chimney breast, the stile abutting thereon being bevel-rebated to receive the plaster at the back and edge. This frame is rebated and beaded on the sight edge to receive the door and is specially provided for hanging the latter, the bead on the face side of the rebate receiving the knuckle of the hinge and relieving the joint.

The stiles of the cupboard frame are made specially wide in order to accommodate a door of satisfactory proportions within the wide recess. An alternative to this would be to use a pair of doors which could be well proportioned to take up the entire width, but it is an advantage to have a good depth of enclosure in a wardrobe not interfered with by the door; in this example 9½″ on each side are made available by using the single door. The stiles are 10¼″ wide and the top rails are 5½″ and 2½″ respectively; these are jointed by tenons on the rails about 5″ long, closely fitted, glued, and screwed from behind; foxtail wedging might be adopted as an alternative with a shorter tenon—see detail at A. In any case mortices could not conveniently be driven through 10″ of material.

Two top rails are used for convenience of jointing, being prefer-


DETAIL Nº: 118.
THE HOUSE.
WARDROBE CUPBOARDS
IN PRINCIPAL BEDROOMS.
FACE OF CHIMNEY BREAST
11¼"
¾" COVER BOARDS.
5½"x1¼" CORNICE
2½"x1½"
2"x1" BEARERS
3½"x1½" ARCHITRAVE
½" SOFFIT BOARDING
½" COVER BOARD
5½"x1½" HEAD
6¼"x⅞" BACK RAIL.
8½"x1½" SHAPED TOP RAIL OF DOOR
"C"
⅜" BACKING.
"B"
MIRROR
⅜" BACKING
ALTERNATIVE METHOD OF SECURING MIRROR
WEDGES
"A"
FOX TAIL WEDGE TENON JOINT.
⅞" PANEL
7' 4½"
MIRROR
6'6"
2'6"
3'8"
4'3"
SKETCH OF WARDROBE FITTING
2' 0¾"
HARD WOOD FILLET.
CENTRE LINE OF DOOR
MIRROR
7"
3½"
1' 3"
2' 1½"
PART PLAN OF WARDROBE FRAMING.
SCALE OF INCHES.
1 0 1 2 3 4 5 6 9 12 15 18

able to one wide rail; the upper one is necessary to support the 2″ × 1″ bearers for receiving the cover boarding to the enclosure. This covering is of ¾″ matched boards (or of ¼″ plywood), laid on the bearers, the latter being 1′ 6″ apart and supported at the back by a 6½″ × ⅞″ pin rail to which they are dovetailed. At the front they are notched over the head of the cupboard frame. The front ends of the top bearers are cut to a bevel to receive the splayed back of the cornice. On the inside, a ½″ matched soffit (or plywood soffit) is provided to enclose the bearers and render the top more dust proof.

385. Cornice and architrave to wardrobes. A marginal architrave mould, 3½″ × 1½″, terminating upon 7½″ × 4″ × 1¾″ foot blocks, is placed round the cupboard frame and covers much of its width, the exposed margin of the frame being reduced to 7″. The cornice is 3″ deep and projects 2¾″ beyond the architrave and may be obtained from 1¼″ material, 5½″ wide. One end abuts squarely against the wall and the other is mitred and returned at the breast, as shown in the perspective detail.

The cornice and the architrave would be of the same general character as other permanent features in the room, in order to harmonise with them.

386. Wardrobe cupboard door. The cupboard door is of the same thickness as the frame, viz. 1½″, and is prepared with 4″ stiles, 7½″ bottom rail, 5½″ middle rail and a top rail of 8″ material shaped and moulded like the rest of the framing, as shown in perspective and sectional details.

A plain mirror of $\frac{3}{16}$″ polished plate, reaching to within 1′ 9″ of the floor, is inserted in rebates as shown in section at B, and protected by a ⅜″ wood backing held in position by rebated slips and secured by screwing to the framing at the overlap. An alternative method of fixing and protecting the mirror is shown at C where a double rebate is provided allowing the back board to overlap the mirror so that its edges may be screwed directly to the framing.

By using a plain mirror with square edges the glass may have a rectangular top, passing behind the shaped sight edge of the top rail and into a straight rebate. If a bevelled mirror is required the rebate at the head must follow the outline of the sight edge, as mitres would occur in the bevels at the changes of direction in the outline.

Care must be taken to paint the glazing rebate with a dead back paint before inserting the mirror and similarly to paint the edges of the mirror. This prevents the rebate surface and any irregularities in the edge of the glass from being reflected and observed in

the mirror. Bevel edged mirrors do not require this if properly ground to a thin edge and finished off to a straight or uniform line.

To prevent breakage of glass in doors and movable frames, it is often bedded upon strips of chamois leather, or of felt, laid in the rebates. These absorb the shock and reduce the risk of breakage. The material should be dyed or stained black after glueing into the rebate, where required to receive square edged glazing.

CHAPTER SEVENTEEN

JOINERY

Windows and Skylights

Casements opening inwards

The relative advantages of these casements as compared with those opening outwards are fully discussed in Vol. III, in relation to French casements. At present it is sufficient to note that inward opening casements are easily accessible for cleaning and are not so liable to damage if left open in a wind, but they are more difficult to make weathertight and interfere with blinds and curtains.

387. Inward opening casement to cycle store. Detail No. 119 shows an ordinary casement made to open inwards and fixed in a brick opening 3′ 8½″ high by 2′ 7½″ wide between square jambs.

The 3″ × 3″ frame is rebated, moulded and beaded and the 4½″ × 3″ oak cill is bevel-rebated, weathered, throated and fitted with a metal water bar, a large overhang being given to the oak cill at the weathering of the brick cill beneath it.

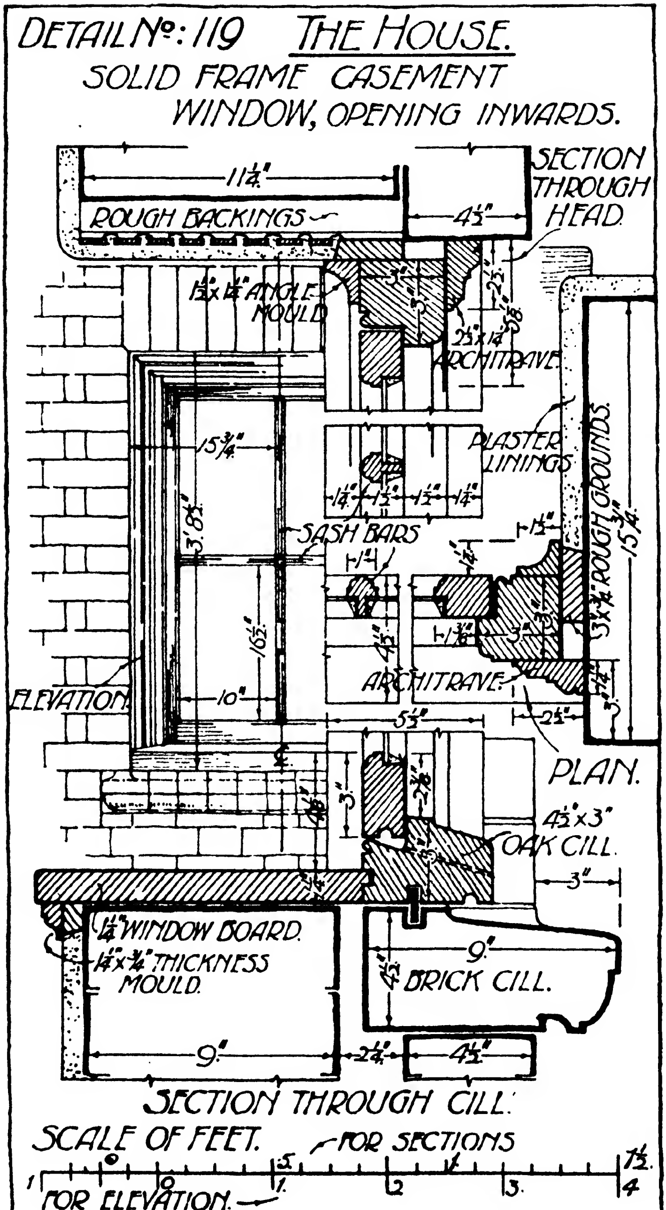
To fix the frame, rough vertical grounds, 3″ × ¾″, are plugged to the sides of the opening as shown, so that posts fit neatly between. The frame may be screwed to the grounds through the rebate or nailed through both to the plugs.

The frame is set 3″ within the recess and a 2½″ × 1¼″ architrave mitred round sides and top of the opening and bevelled upon the cill.

On the inside a cover mould is placed in the angle to overlap the rough ground when the plastering of the jamb is complete.

388. Treatment of cill. The simplest method of making an inward opening cill weathertight is shown here. The cill rebate is bevelled inwards and made to slope a little each way towards the centre of the length. Any water entering the rebate is then collected and conveyed to the outside through an inclined channel preferably lined with a stout brass or copper tube.

This method serves very well for unexposed situations or when the fitting of the sash is well done and the sash made to close tight against the rebate. For exposed situations one of the methods shown in Vol. III should be adopted.


DETAIL No: 119 THE HOUSE.
SOLID FRAME CASEMENT WINDOW, OPENING INWARDS.
SECTION THROUGH HEAD
ROUGH BACKINGS
1½"x1¼" ANGLE MOULD
2½"x1¼" ARCHITRAVE.
PLASTER LININGS
SASH BARS
3"x¾" ROUGH GROUNDS.
ARCHITRAVE.
ELEVATION.
PLAN.
4½"x3" OAK CILL.
1¼" WINDOW BOARD.
1¼"x¾" THICKNESS MOULD.
BRICK CILL.
SECTION THROUGH CILL.
SCALE OF FEET.
FOR SECTIONS
FOR ELEVATION.

389. Centre-hung or pivoted sashes. The true pivoted sash is one occupying a complete opening, set within a thicker frame and made to rotate upon centres set at or near the middle of its height; it is therefore often termed a centre-hung sash.

Similar opening parts, being portions only of a window, are referred to as pivoted or centre-hung "lights".

The open window can be made to give a large or small opening for ventilation by adjustment of its position and when tilted to its maximum, viz. about 10° short of the horizontal, the entire opening is practically available for admission of air.

The only objection is that the window must be open at the top and bottom at the same time, as seen by the perspective detail No. 120.

These windows are very suitable for the ventilation of large staircases, landings, stables, cowsheds, etc., and are easily manipulated either by a cord attached to eyelets in the stile near the top and bottom edges of the sash and secured to a cleat, or, where more easily accessible, by a wrought iron opener, as shown for the "typed sash" in Vol. I.

390. Frame for centre-hung sash. The frame is composed of $4'' \times 2\frac{1}{2}''$ stiles and head and a $5'' \times 3\frac{1}{2}''$ oak cill. The latter is moulded, sunk and weathered, but the remainder of the frame has plain square edges.

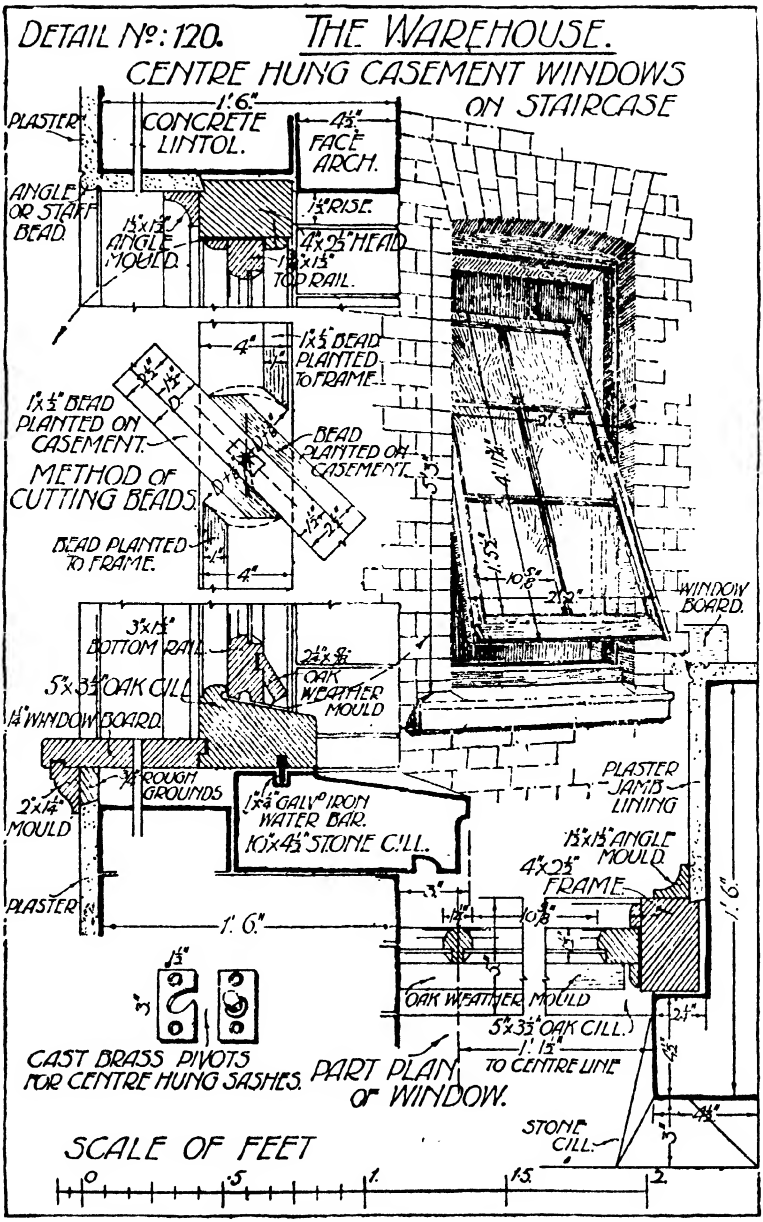
The jointing of this frame is similar to all solid window frames, the cill and head being morticed and the posts tenoned.

Owing to the fact that the upper and lower parts of the sash move in opposite directions, the frame cannot be conveniently solid rebated as is usual with window and door frames, except by increasing the labour upon their preparation, hence the rebates are formed by separate beads or moulds, cut and nailed in position as required.

391. Sash and planted beads. The section in detail No. 120 shows the open sash with the planted beads in position. It is clear that by setting the sash in the middle of the frame and placing a bead on each side to form the rebate, the portions of bead nailed to the frame on the outer side must be at the top and on the inner side at the bottom of the opening.

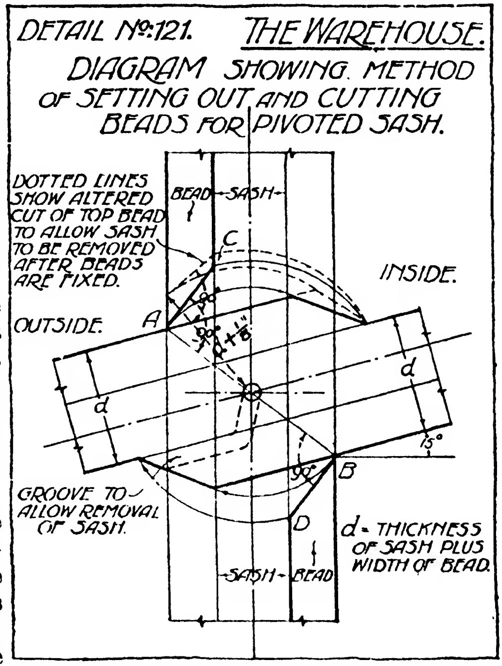
The problem to solve is, while continuing the beads in an apparently unbroken line round both sides, as seen when the window is closed, to cut and fix them so that if the sash rotates there is no obstruction to movement and yet a maximum cover for protection against driving rain is obtained.

392. To obtain cuts for beads. Let the sash in detail No. 121 be opened to its maximum position carrying those portions of the


DETAIL No: 120.
THE WAREHOUSE.
CENTRE HUNG CASEMENT WINDOWS ON STAIRCASE
PLASTER
CONCRETE LINTOL.
FACE ARCH.
ANGLE OR STAFF BEAD.
ANGLE MOULD.
HEAD
TOP RAIL.
BEAD PLANTED TO FRAME
BEAD PLANTED ON CASEMENT.
METHOD OF CUTTING BEADS.
BEAD PLANTED ON CASEMENT.
BEAD PLANTED TO FRAME.
WINDOW BOARD.
BOTTOM RAIL
OAK CILL
WINDOW BOARD.
OAK WEATHER MOULD
ROUGH GROUNDS
MOULD
GALVd IRON WATER BAR.
STONE CILL.
PLASTER
PLASTER JAMB LINING
ANGLE MOULD.
FRAME.
OAK WEATHER MOULD
OAK CILL.
TO CENTRE LINE
CAST BRASS PIVOTS FOR CENTRE HUNG SASHES.
PART PLAN OF WINDOW.
STONE CILL.
SCALE OF FEET

beads with it which are not nailed to the frame. Note the point A where the original outer edge line of the bead cuts the new position of the line. Join A to the centre of rotation and produce to intersect the edge of the inner bead at B; make the sloping cut at 90° to AB, as shown at AC and BD.

This gives the flattest angle which will allow the moving bead to clear the fixed one so that the joint shall be quite close when the window is shut.



If the window sash may be inserted before the beads are nailed on to the frame, the above position is satisfactory but for subsequent removal of the sash it may be desirable to cut the outer bead at a higher level so that the thickness d of the sash and bead will pass the pin and slide into position along the slot in the bead, which continues and guides the pin across the thickness of the sash to the socketted plate, as shown in dotted lines.

To ensure clearance of the joint when opening, the distance between the pin and the splayed end of the upper bead should be $d + \frac{1}{8}''$.

The mould on the inside of the cill is of the same form as the planted beads so that the two will mitre together at their junction.

393. Sash centres. The centre of rotation is selected at the middle of the thickness of the sash and slightly above its centre of gravity; this causes the sash to close as soon as the pull on the cord or fastener is released.

The sash centres employed are shown in the lower corner of detail No. 120; they may be of cast iron, brass, or gun metal. The pin is screwed to the frame and the socket to the sash, with the open end downwards and inwards, so that as the frame rotates there can be no danger of the sash withdrawing.

394. Weather mould. For assistance in repelling driving rain and forming a protection to the bottom rail and cill joint, an oak weather mould is sometimes tongued to the rail as shown. This is not always necessary, especially with a double sunk cill, if the outer sinking is flush with the face of the sash. It is a good method of improving a defective cill joint in existing windows.

WINDOWS

Cased frames and sliding sashes

Examples of cased frames with double hung sliding sashes have already been given in Vol. I, where the application was made to ordinary cases.

The detail No. 122 shows an application of such sashes to square stopped jambs in place of the usual rebated jambs.

395. Cased frames and sliding sashes to principal windows of house. The window openings to the house are prepared with square jambs in the cavity walls, which are $15\frac{3}{4}''$ thick, the cased frames being made to fit neatly within the openings so that the outer lining of the frame is $3''$ from the face of the wall.

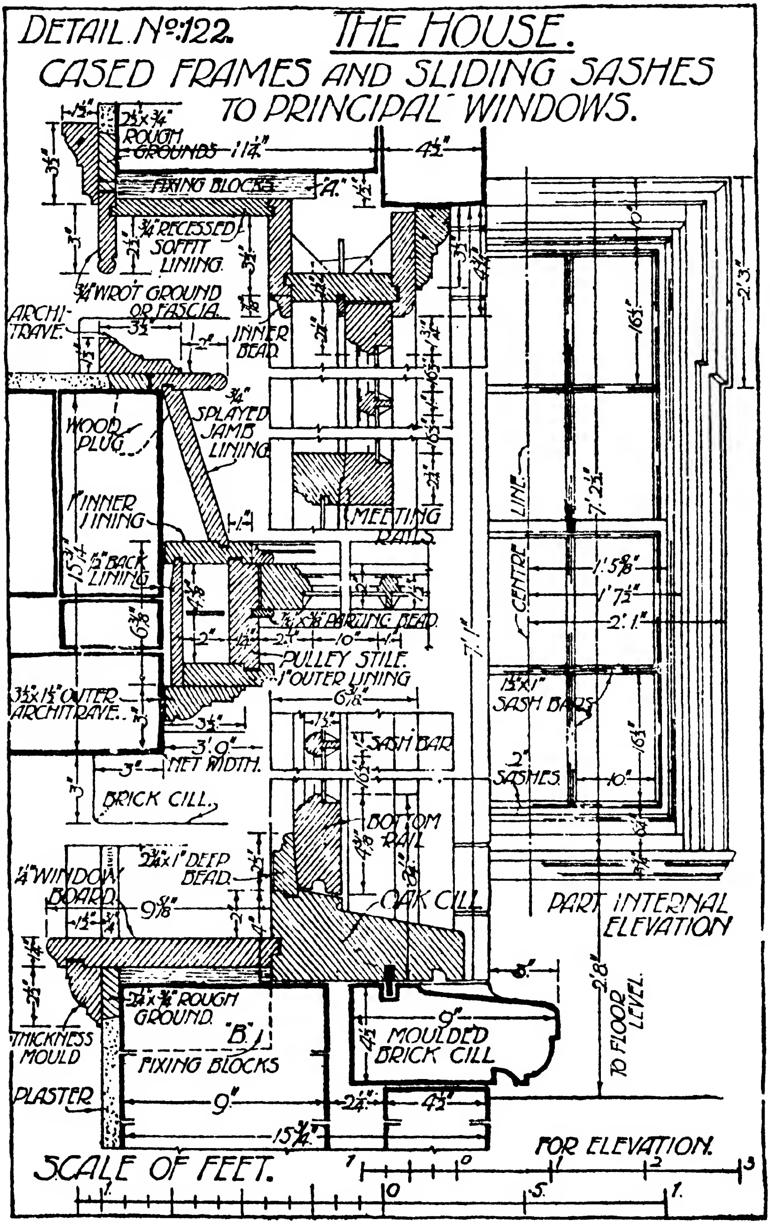
A $3\frac{1}{2}'' \times 1\frac{1}{2}''$ architrave is fitted outside this, close against the brickwork, and terminates at the cill upon the weathering.

The entire window then appears to be very near the outside face and a maximum of light is admitted if bevelled jamb linings are employed without obstructions such as internal projection of fascias, etc.

396. Construction of frame. The frame consists of $4\frac{3}{4}'' \times 1\frac{1}{4}''$ pulley stiles and head, $8\frac{1}{4}'' \times 4''$ oak cill, and linings to the weight cases $4''$ to $4\frac{1}{2}''$ wide $\times 1''$ thick; the weight cases are about $2''$ square, divided by a $1\frac{3}{4}'' \times \frac{1}{4}''$ parting slip and enclosed by a $\frac{1}{2}''$ back lining, all as shown in the detail. The inside and outside head linings are necessarily wide to allow the outer one to receive the architrave, and the inner one to receive the soffit lining sufficiently high to form a blind or curtain recess; these head linings are blocked to the head of the frame to obtain sufficient rigidity.

The cill is single sunk, weathered and throated and projects $2''$ beyond the frame and over the weathering of the brick cill.

To divide the sashes $\frac{7}{8}'' \times \frac{3}{8}''$ parting beads are grooved into the pulley stiles and head, and to enclose the inner and lower sash a $\frac{7}{8}'' \times \frac{7}{8}''$ moulded staff bead or inner bead is employed, which fits into a rebate formed by keeping the edge of the inside lining $\frac{1}{4}''$ from the face of the head. Instead of running this bead across the cill, a similarly moulded deep bead, $2\frac{3}{4}'' \times 1''$, is tongued into the cill and bevelled on the inside. This forms a second weather check,


DETAIL. No. 122. THE HOUSE.
CASED FRAMES AND SLIDING SASHES TO PRINCIPAL WINDOWS.
ROUGH GROUNDS
FIXING BLOCKS
"A."
¾" RECESSED SOFFIT LINING.
¾" WROT GROUND OR FASCIA.
ARCHITRAVE.
INNER BEAD
SPLAYED JAMB LINING
WOOD PLUG
INNER LINING
MEETING RAILS.
½" BACK LINING
PARTING BEAD
PULLEY STILE.
1" OUTER LINING
OUTER ARCHITRAVE.
3'.9" NET WIDTH.
SASH BAR
BRICK CILL.
BOTTOM RAIL
DEEP BEAD.
WINDOW BOARD
OAK CILL.
ROUGH GROUND.
"B."
THICKNESS MOULD
FIXING BLOCKS
PLASTER
MOULDED BRICK CILL.
CENTRE LINE
SASH BARS
2" SASHES.
PART INTERNAL ELEVATION
TO FLOOR LEVEL.
SCALE OF FEET.
FOR ELEVATION.

and acts as a ventilating piece by allowing the sash to be raised to admit air at the meeting rails while preventing a direct entry of air beneath the sash, and also provides a tightening joint for the sash cill which is similarly bevelled to close against it.

397. Arrangement and construction of sashes. The sashes are 2″ thick, with solid bevel-rebated meeting rails $2\frac{1}{4}''$ deep on face and a $4\frac{3}{8}''$ deep bottom rail which is necessary to allow sash lifts to be fixed. These sashes are divided by moulded bars, $1\frac{1}{2}'' \times 1''$, the mould agreeing with the inner member of the mould on the main sash framing; the ogee mould on the latter does not affect the bars which are inset $\frac{1}{2}''$ from the face, but forms a rim to the entire sash and emphasises the main outline. This arrangement causes the sash bars to have a light and subsidiary appearance.

The sashes would be jointed in the manner shown in full detail in Vol. I, with the exception of modifications such as widths of tenons to clear the moulds at their edges and differing lengths of shoulder due to the moulding being deeper than the rebate. The student should sketch these out in detail for practice in deciding upon suitable forms of joint for any given conditions of design.

398. Internal finishings to cased frames. These consist of splayed side linings, level soffit lining and compound architraves, forming curtain and blind recesses.

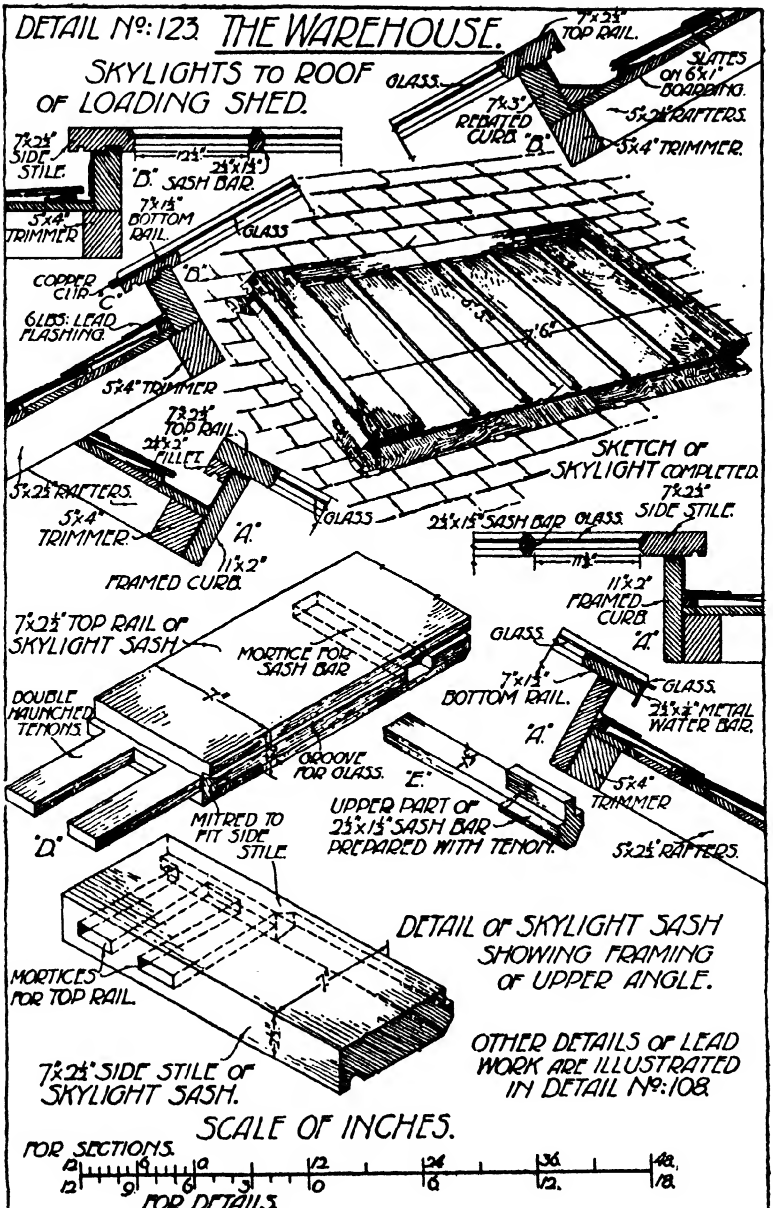
The linings are tongued on both edges to the window frame and architrave fascia respectively, the latter projecting into the opening and giving a cover for curtains at the sides and head. The fascia, also called a wrought ground, is the same thickness and therefore lies in the same plane as the rough ground in each case; the rough ground is covered and the plaster at the joint hidden by a $3\frac{1}{2}'' \times 1\frac{1}{2}''$ architrave, broken to form ears at the top.

A $1\frac{1}{4}''$ moulded window board receives the bottom ends of the architraves and a $2\frac{1}{2}'' \times 1\frac{1}{2}''$ tongued thickness mould supports and finishes the projection of the window board.

The rough grounds should be framed together as recommended for other door and window openings and fixed to plugs in the brickwork. If well plugged to the jambs the horizontal members need no intermediate support except in wide openings, when fixing blocks may be used at intervals, as shown at A and B.

Skylights

A skylight is a glazed frame for the admission of light, placed approximately parallel to the roof on which it rests; when applied to a flat roof it must be raised sufficiently to give it a reasonable fall as well as to enable the sides to be weatherproofed.


DETAIL Nº: 123. THE WAREHOUSE.
SKYLIGHTS TO ROOF OF LOADING SHED.
7"x2½" TOP RAIL.
GLASS.
SLATES ON 6"x1" BOARDING.
7"x3" REBATED CURB "B".
5"x2½" RAFTERS.
5"x4" TRIMMER.
7"x2½" SIDE STILE.
12½"
2½"x1½"
"B". SASH BAR.
5"x4" TRIMMER
7"x1½" BOTTOM RAIL.
GLASS
"B".
COPPER CLIP.
"C"
6LBS: LEAD FLASHING.
5"x4" TRIMMER
7"x2½" TOP RAIL.
2½"x2" FILLET.
5"x2½" RAFTERS.
5"x4" TRIMMER.
"A".
11"x2" FRAMED CURB.
GLASS
2½"x1½" SASH BAR
GLASS.
SKETCH OF SKYLIGHT COMPLETED.
7"x2½" SIDE STILE.
11½"
11"x2" FRAMED CURB
"A".
7"x2½" TOP RAIL OF SKYLIGHT SASH.
MORTICE FOR SASH BAR
DOUBLE HAUNCHED TENONS.
"D".
GROOVE FOR GLASS.
MITRED TO FIT SIDE STILE.
"E".
UPPER PART OF 2½"x1½" SASH BAR PREPARED WITH TENON.
GLASS.
7"x1½" BOTTOM RAIL.
"A".
GLASS.
2½"x¼" METAL WATER BAR.
5"x4" TRIMMER.
5"x2½" RAFTERS.
MORTICES FOR TOP RAIL.
7"x2½" SIDE STILE OF SKYLIGHT SASH.
DETAIL OF SKYLIGHT SASH SHOWING FRAMING OF UPPER ANGLE.
OTHER DETAILS OF LEAD WORK ARE ILLUSTRATED IN DETAIL Nº: 108.
SCALE OF INCHES.
FOR SECTIONS.
12 6 0 12 24 36 48
12 9 6 3 0 6 12 18
FOR DETAILS.

399. Use of skylights. While skylights are often necessary adjuncts to town dwellings and offices which have confined sites (where light is only available from front and back), they should, as far as possible, be avoided in buildings which can be lighted from three or more sides. If proper care be exercised in preparing designs these features can usually be eliminated.

Industrial buildings, such as factories, workshops and warehouses, often need direct overhead light and roof lights may be indispensable.

The perspective detail of the house roof, No. 99, shows two skylights. That on the sloping roof provides light to the cistern room and could readily have been replaced by a small dormer. An opening on the flat roof would have been required for access to the lead flat, and the opportunity has been taken of showing the construction of an opening skylight and using it for lighting the attic stair, which has been removed from the main staircase for that purpose.

400. Fixed skylight. An example of a fixed light applied to the roof of the loading shed is shown in detail 123.

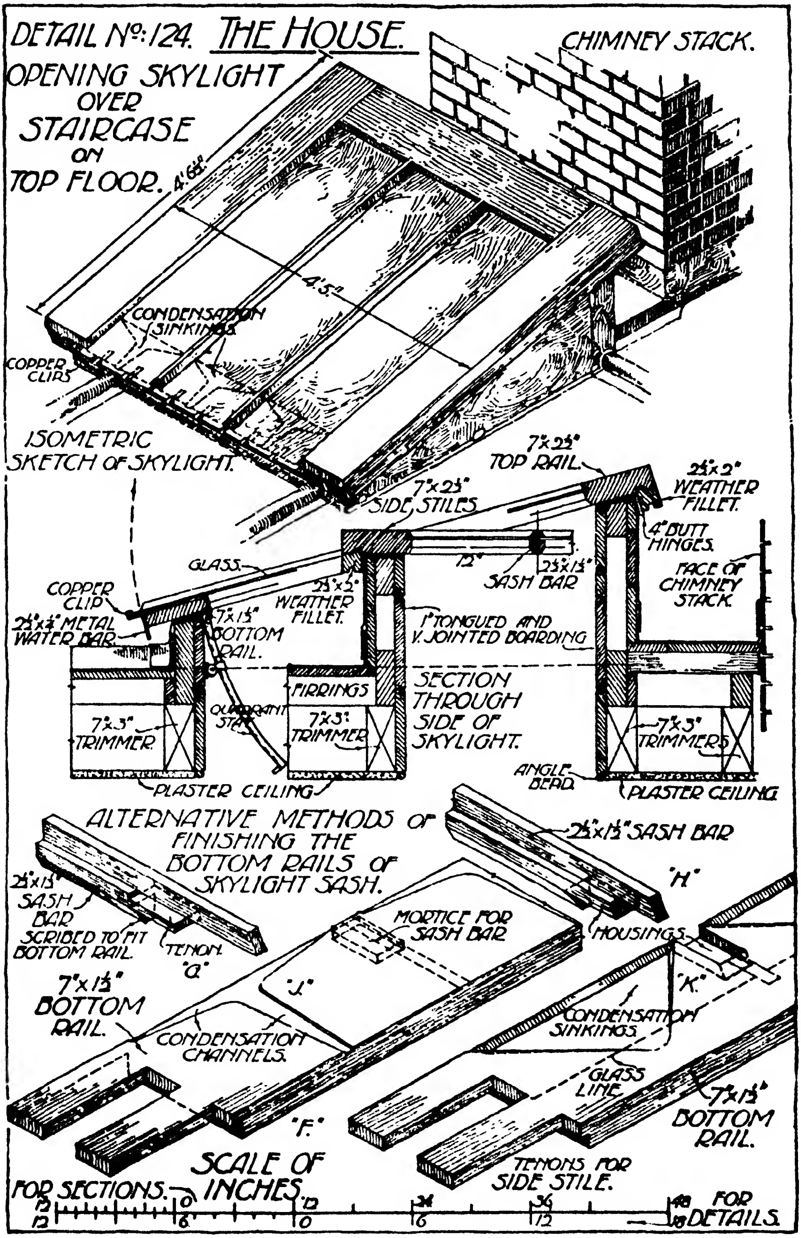
The carpentry preparation consists of an opening framed in the rafters and lined by 11″ × 2″ wrought and beaded curbs, as illustrated at A, or, as an alternative, 7″ × 3″ curbs may be fixed upon the top sides of the trimming rafters and trimmers, as shown at B. The object is to raise the top edge of the curbs well above the roof plane in order to form a gutter along the back of the light.

The "light" consists of 2½″ rebated and chamfered framing with 7″ × 2½″ stiles and top rail and a 7″ × 1½″ bottom rail, which is made thinner in order to allow the glazing to continue across its upper surface and in the plane of the rebates, or slightly below it, as may be seen at C.

The curbs are tongued to the light in the upper section and the light overhangs 2½″ to allow of throatings to all edges. In the lower section the overhang at the gutter is improved by a throated fillet which is bedded in thick paint and well screwed to the head; this would allow of hinging for an opening light, if desired. The drip at the bottom rail is formed by a 2½″ × ¼″ metal bar screwed to the front edge.

Preparation for clearing condensed moisture and for supporting the glass at the foot is made by having the glazing rebates of the stiles and bars a little higher than the surface of the bottom rail. Copper clips can then be screwed within this space and turned over the overhanging edge of the glazing.

401. Joints in skylight framing. The joints between the parts of the framing are shown in the lower part of detail No. 123. The



DETAIL Nº: 124. THE HOUSE.
OPENING SKYLIGHT OVER STAIRCASE ON TOP FLOOR.
CHIMNEY STACK.
4'6½"
4'5"
CONDENSATION SINKINGS
COPPER CLIPS
ISOMETRIC SKETCH OF SKYLIGHT.
7"x2½" TOP RAIL.
2½"x2" WEATHER FILLET.
7"x2½" SIDE STILES
4" BUTT HINGES.
FACE OF CHIMNEY STACK.
GLASS
12"
2½"x1½" SASH BAR
COPPER CLIP
2½"x¼" METAL WATER BAR.
2½"x2" WEATHER FILLET.
7"x1½" BOTTOM RAIL.
1" TONGUED AND V. JOINTED BOARDING
FIRRINGS
QUADRANT STAY
7"x3" TRIMMER
7"x3" TRIMMER
SECTION THROUGH SIDE OF SKYLIGHT.
7"x3" TRIMMERS
ANGLE BEAD
PLASTER CEILING
PLASTER CEILING
ALTERNATIVE METHODS OF FINISHING THE BOTTOM RAILS OF SKYLIGHT SASH.
2½"x1½" SASH BAR
2½"x1½" SASH BAR SCRIBED TO FIT BOTTOM RAIL.
TENON.
"G"
"H"
MORTICE FOR SASH BAR
HOUSINGS
"J"
"K"
7"x1½" BOTTOM RAIL.
CONDENSATION CHANNELS.
CONDENSATION SINKINGS
GLASS LINE
7"x1½" BOTTOM RAIL.
"F"
TENONS FOR SIDE STILE.
SCALE OF INCHES.
FOR SECTIONS.
FOR DETAILS.

junction between the top rail and stile is shown at D, where double haunched tenons are employed. The top joint of the sash bar is given at E. At the bottom rail joint, double haunched, barefaced tenons are necessary as at F, while alternative forms of joints for the foot of the sash bar are shown at G and H, the former having a tenon and continued rebate piece, while the latter is bevel housed to the top of the rail.

Alternative forms of condensation channels are shown at J and K, the former presuming that the glass overhangs the whole of the rail and is seated directly upon it, while in the latter it is kept back about 3″ from the edge. These provisions allow for escape of condensation while having small outlets which reduce draughts to a minimum.

Actual contact between bottom rail and glass should be avoided because warping of the rail may cause fracture.

The upper part of detail No. 124 gives particulars of the opening skylight over the staircase on the top floor. The sash is similar to that described in the last paragraph, except that tongued weather fillets are placed around the sides and top rail. Hinges are fixed between the weather fillet at the back boarding of the curb and are thus efficiently protected.

Finishings to skylight. The rough carpentry framework, described in paragraph 400, is covered with 1″ ploughed and tongued and V-jointed boarding and is finished with an angle or staff bead to the plain plaster ceiling.

The description of the lead work for this case is given under Plumbing in Vol. III.

A skylight similar to that detailed at No. 123 might be used in the roof over the cistern room, but a cast iron skylight frame has been selected for application; see detail No. 58.

CHAPTER EIGHTEEN

JOINERY

Stairs

402. General design of stairs. In all classes of buildings the stairs and staircase provide scope for the indication of the distinctive character of the building.

Usually it is the first feature of importance within the main entrance, and as such should demand the particular attention and study of architects and builders.

The importance of properly lighting and ventilating a staircase has already been emphasised, and the former should constitute an integral part of the design.

It is generally convenient to plan all the main stairs to a building within one staircase and in large buildings to provide additional staircases for communication between the floors without undue waste of time and effort.

In most large buildings stairs are supplemented by passenger and goods lifts.

In small buildings the ground floor stair is usually made the chief feature but the same type of design, though possibly of simpler form, should be adopted for the upper floors. Basement stairs may sometimes be treated quite independently from the main stairs as it is often possible either to separate them entirely, or to screen them from the principal stairs.

Basement stairs are commonly of stone or concrete, but in the following examples a wooden stair has been adopted in order to provide an example of winder construction along with a strong and simple framing.

Wooden Stairs to House

The whole of the stairs to the house are constructed of timber and all differ in the form of plan from the straight stair in one single flight, which was fully detailed in Vol. I.

403. Stairs with winders. Triangular or tapered treads, called "winders" or "turn treads", are often necessary where the space containing the stair is limited in some respects, such as in length, position of access and approach.

Winders are not a desirable feature but they need not be dangerous nor necessarily avoided if planned so as to give a reasonable width

to the step near the centre. Wherever necessary they should, if possible, be placed at the foot of the stairs.

Considering the average position of the walking line as being at the middle of stairs up to 3′ 0″ in width, the width of the tread at this line should be approximately equal to that of a flier. Stairs wider than 3 ft. should generally be arranged without winders.

404. Basement stair to house. The basement stair to the house leads down from a side door in the hall and lands the user at the basement level in a direction facing across the width of the room. In order to obtain as much floor space as possible in the basement a right-angled turn, with four winders, is made at the foot of the flight.

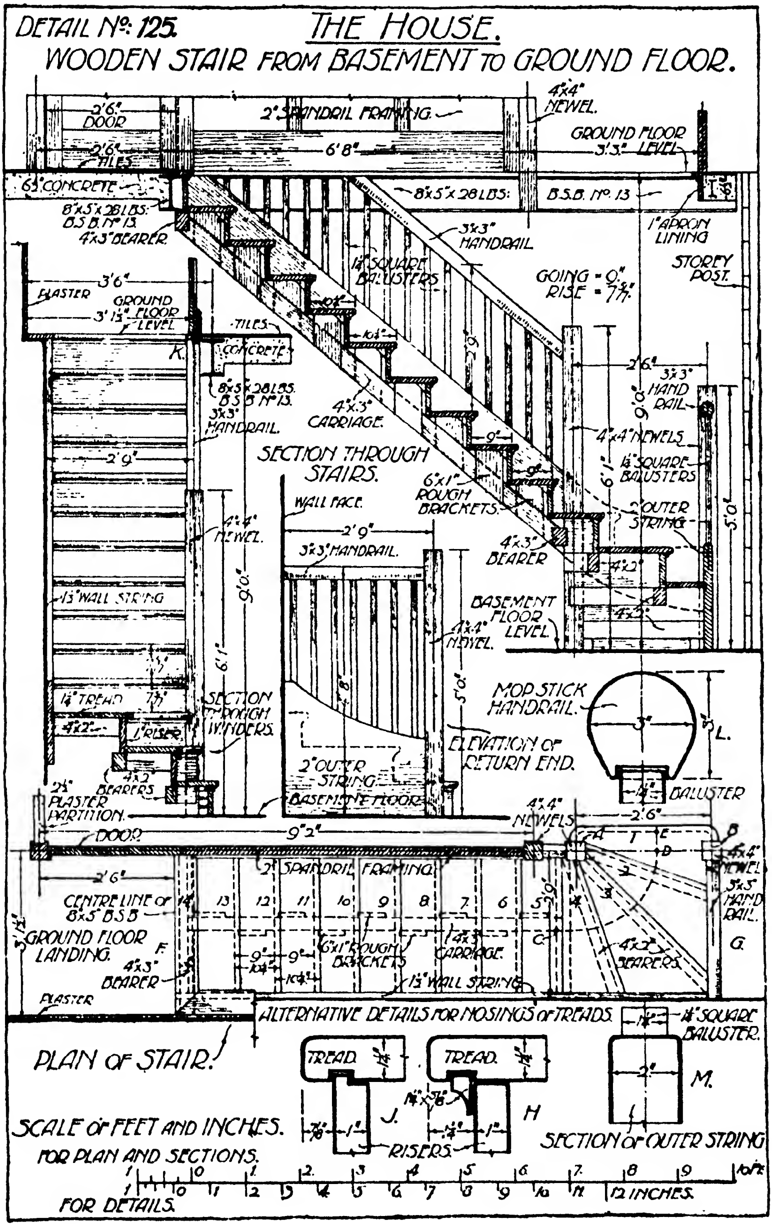
The space for containing the stair in plan extends 9′ 11″ from the centre of the girder at the stair head to the centre of the short string at the foot of the flight, and 2′ 9″ in width from the side wall of the basement to the centre of the outer string.

The lift or rise of the stair is 9′ 0″ from basement to ground floor, requiring 14 risers at $7\frac{5}{7}''$ rise each. Thus, if nine straight steps be used, with 9″ going and requiring a run of 6′ 9″ and adding to this the half-width of top girder plus the thickness of the riser, viz. $2\frac{1}{2}'' + 1'' = 3\frac{1}{2}''$, there is a length of 7′ $0\frac{1}{2}''$ occupied, leaving 2′ $10\frac{1}{2}''$ for the winders measured from the last straight riser to the centre of the end string.

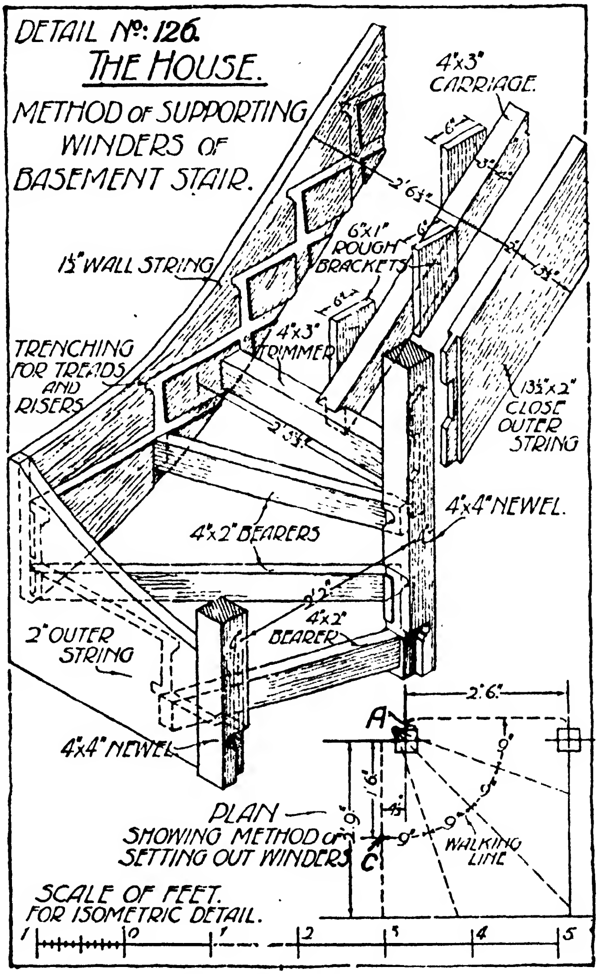
405. Plan and section of stair. The plan and section of the stair show the setting out to these dimensions. Floor to floor height in the section is set out and divided into fourteen equal divisions on a storey post, shown to the right of detail No. 125, while the plan is subdivided geometrically between the limits for the straight stair. Projections from these pairs of divisions will produce the outlines of the steps in section, minus the nosings. The details of treads and risers, with the projecting nosing and scotia, can then be filled for the straight flight and the plans of the nosings obtained.

406. Position of winders. The newel post A which supports the end of the exposed or outer string is placed in the centre of the latter and 2′ 6″ distant centre to centre from the newel B. This width leaves 2′ 2″ between the posts.

The winders are set out by first striking a quadrant of a circle of 1′ 8″ radius from the outer corner of newel A and continuing the tangents at the extremities of this curve to the straight step at C, and indefinitely at the bottom end from D. Commencing from the first straight riser C, mark off the going of the winders along this quadrant, and draw the face line of the risers through these points


DETAIL No. 125. THE HOUSE.
WOODEN STAIR FROM BASEMENT TO GROUND FLOOR.
2'6" DOOR
2" SPANDRIL FRAMING
4"x4" NEWEL.
GROUND FLOOR LEVEL
6'8"
2'6" TILES
6½" CONCRETE
8"x5"x 28 LBS: B.S.B. No. 13
8"x5"x28LBS: B.S.B. No. 13
4"x3" BEARER
1" APRON LINING
3"x3" HANDRAIL
STOREY POST.
1½" SQUARE BALUSTERS
GOING = 9". RISE = 7⅞".
PLASTER
GROUND FLOOR LEVEL
TILES
CONCRETE
K.
4"x3" CARRIAGE.
3"x3" HANDRAIL.
2'9"
SECTION THROUGH STAIRS.
9'0"
6'1"
3"x3" HAND RAIL
4"x4" NEWELS
1½" SQUARE BALUSTERS
2" OUTER STRING
6"x1" ROUGH BRACKETS.
WALL FACE.
4"x4" NEWEL.
4"x3" BEARER
5'0"
3"x3" HANDRAIL.
1½" WALL STRING
BASEMENT FLOOR LEVEL
4"x4" NEWEL.
MOP STICK HANDRAIL.
L.
1½" TREAD
1" RISER
SECTION THROUGH WINDERS.
ELEVATION OF RETURN END.
2" OUTER STRING
BASEMENT FLOOR
4"x2" BEARERS
BALUSTER
2½" PLASTER PARTITION.
DOOR
9'2"
4"x4" NEWELS
2'6"
2" SPANDRIL FRAMING
CENTRE LINE OF 8"x5" B.S.B.
14 13 12 11 10 9 8 7 6 5
3"x3" HAND RAIL.
GROUND FLOOR LANDING.
F.
4"x3" BEARER
6"x1" ROUGH BRACKETS
4"x3" CARRIAGE.
1½" WALL STRING
4"x2" BEARERS
G.
PLASTER
ALTERNATIVE DETAILS FOR NOSINGS OF TREADS.
1½" SQUARE BALUSTER.
PLAN OF STAIR.
TREAD
TREAD
J.
H
M.
RISERS
SECTION OF OUTER STRING
SCALE OF FEET AND INCHES.
FOR PLAN AND SECTIONS.
FOR DETAILS.
12 INCHES.

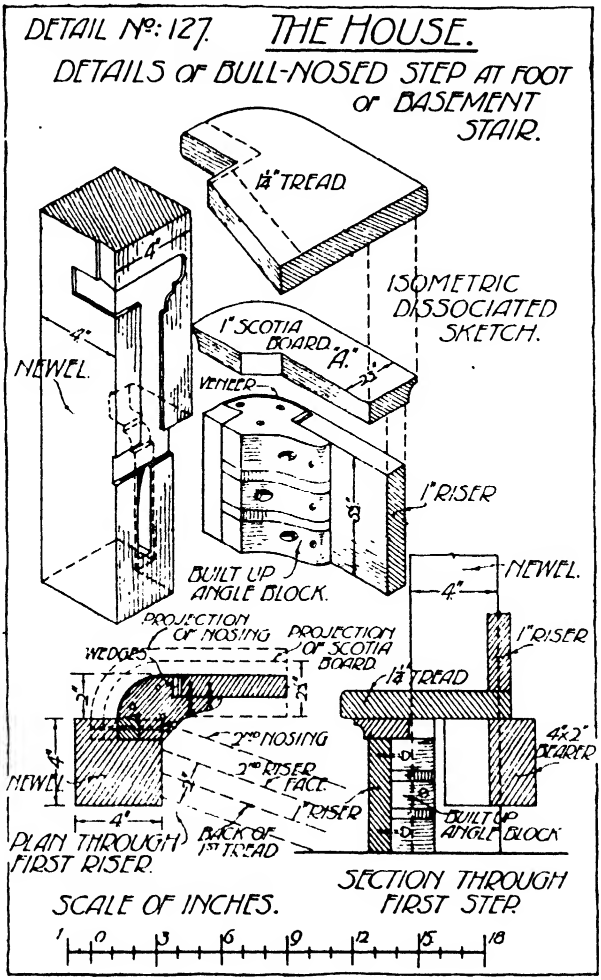
to the centre of the quadrant, as shown in the lower part of detail No. 126. The last division reaches E (detail No. 125) and thus a projecting bottom step is required to maintain the minimum widths of winders.



407. Section of winders. The section of the stair can now be completed through a selected line, *e.g.* FG in plan, the position and projection of riser and nosing being obtainable therefrom.

A sectional elevation of the stair across the centre of the winders in the opposite direction is given to the left and shows how the

nosings and scotia moulds die upon the face of the newel post, to which they are housed in the best work, as shown in the isometric detail No. 127.



408. Construction of stair. The stair is constructed in a manner similar to that described in Vol. I.

Treads and risers are $1\frac{1}{4}''$ and $1''$ thick respectively, jointed at the top angle as shown at H, or alternatively as at J in detail No. 280, but with a tread $9\frac{7}{8}''$ wide, and at the lower angle by tongueing the back of the tread to the riser. Treads and risers are housed to the

strings to a depth of $\frac{1}{2}''$ and wedged, as shown by the tapered housings of the trenched string in detail No. 126.

The strings are $13\frac{1}{2}''$ wide to obtain a depth for enclosing the rough carriage at the centre of the steps, the wall string being $1\frac{1}{2}''$ and the outer string $2''$ thick. The latter is cut to rest on the girder flange at the head and at the foot is oblique tenoned to the newel post, as detailed.

To accommodate the winders the wall string is curved and deepened as seen in the sectional elevation of the stair in details Nos. 125 and 126. The curve adopted is an arbitrary one obtained by bending a straight lath to the desired curve, clearing the housings above and ensuring sufficient depth to joint with the short return string, which must also have a satisfactory curve.

On the underside the depth must enclose rough bearers, where such are considered necessary, these being commonly from $3'' \times 2''$ to $4'' \times 2''$, placed immediately under the back edge of each winder, housed into the supporting newel and notched also into the curved strings or bevelled against them and nailed, as shown in the isometric detail.

409. Support of rough carriage. The rough carriage bears at the head and foot upon $4'' \times 3''$ bearers, trimmers or pitching pieces framed between the strings. These are seen in the plan and section and the lower one also in detail No. 126. Carriage joists are usually bird's-mouthed only, or if sufficient bearing cannot be obtained are notched in addition. In any case, the jointing must allow for fixing after the stair is erected.

Rough brackets are nailed on alternately opposite sides of the carriage to give support to the treads.

410. Bottom step with bull-nose ends. The projecting front of the bottom step has its ends returned to the posts by forming bull-nose angles. To continue the riser round the curve without change of grain the riser board is cut to a thin veneer, as shown in plan at detail No. 127, bent round a built-up riser block, notched, screwed at one end and wedged tight by folding wedges. The riser block is built up from dry, well-seasoned timber in five pieces, two of these being interleaved with the grain at right angles to the other three; possible change of form is therefore minimised, which is important, because much shrinkage loosens the veneer and causes it to be easily damaged.

In common work these blocks are cut from one solid piece and prepared to receive the riser by notching the angle. The joint is then glued and nailed, but the step does not retain its shape and is unsuitable for good work.

The scotia mould is worked upon the edge of a $1''$ board shaped

to follow the curve of the riser, as shown at A; it is nailed to the shaped end blocks and to the riser, and is blocked from behind.

The tread is similarly shaped at the ends to maintain a projecting parallel curve and in this case, being a winder, tapered to suit the plan.

Observe that the riser block, scotia and tread are housed into the newel post, like all the rest of the step units which intersect it, except in this case to a depth of ½″.

411. Handrail and balusters. The general detail, No. 125, shows the arrangement of the handrail and balusters to the side and end of the basement stair. The inclined side handrail is tenoned and pinned to the newel post and splayed and screwed to the nosing piece shown in section at K, while the level handrail at the base of the stair is tenoned to the post and housed into the wall or secured to a turned patera or circular disc plugged to the wall.

The handrail is 3″ × 3″ and of the "mop stick" pattern shown enlarged at L. It is grooved on the underside to receive the top ends of 1¼″ square balusters; at the base these may either bevel upon the top edge of the string, as given at M, or a moulded overhanging capping may be employed nailed to the string in cases where the latter is less than 2″ thick.

Note: the main stair to the house is detailed in Vol. III.

CHAPTER NINETEEN

JOINERY—INTERNAL FITTINGS

GLAZED SCREENS OR PARTITIONS

412. A "screen" is a form of division between two parts of one room, or one apartment. It may be of a temporary nature, or a permanent fitting; in most cases it does not aim at securing strict privacy but rather at the exclusion of noise, draught and dust, or the division of two groups of labour or again the subdivision of an entrance passage into two parts, *e.g.* a vestibule screen.

For many of these purposes it may be an advantage and in some cases a necessity, that the larger portion of it should be glazed for the admission of light.

413. Glazed partitions to time-keeper's office. The use of glazed partitions has been shown in the formation of a time-keeper's office to the back entrance of the warehouse.

This office is placed between the entrance door and the loading way; it is glazed for about two-thirds of its height on all sides for the purpose of supervision and control and is also lighted by a window in the external wall; the time-keeper's desk could be placed under this window; see general plans and also detail No. 128.

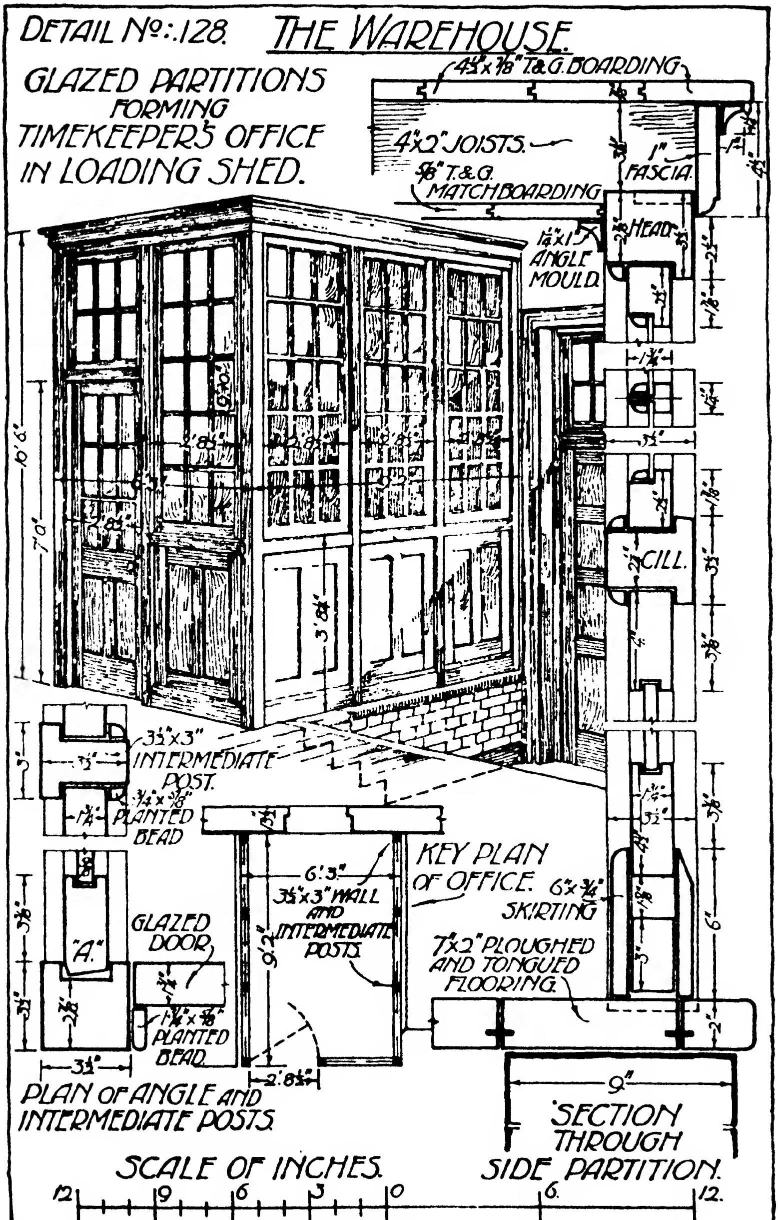
414. Arrangement of screens and ceiling. The screens consist of posts and rails framed into rectangular panels, which are filled in the dado or lower part with wood framing and in the upper part with glazed sashes in small panes.

A doorway is arranged in the end screen and fitted with a $1\frac{3}{4}''$ glazed door to match the detail of the screens.

The ceiling consists of $4\frac{1}{2}'' \times \frac{7}{8}''$ tongued and grooved cover boards, supported upon $4'' \times 2''$ ceiling joists placed across the short span and ceiled with $\frac{5}{8}''$ beaded match-boarding.

415. Screen framing. The framing of the screens consists of $3\frac{1}{2}'' \times 3\frac{1}{2}''$ angle posts and $3\frac{1}{2}'' \times 3''$ wall, door, and intermediate posts; the head, door transome and upper cill (or dado rail) are also $3\frac{1}{2}'' \times 3''$.

In a screen of this size the usual arrangement would be to make the angle, wall and door posts continuous throughout the height, frame the rails in one length between them and the short intermediate posts or muntins between the rails. This would not introduce much that is new in the arrangement of framing and a scheme


DETAIL No.:128.
THE WAREHOUSE.
GLAZED PARTITIONS FORMING TIMEKEEPER'S OFFICE IN LOADING SHED.
4½"x⅞" T.&G. BOARDING
4"x2" JOISTS.
⅝" T.&G. MATCHBOARDING
1" FASCIA
HEAD
1¼"x1" ANGLE MOULD.
CILL.
3½"x3" INTERMEDIATE POST.
¾"x⅝" PLANTED BEAD
KEY PLAN OF OFFICE.
6'3"
3½"x3" WALL AND INTERMEDIATE POSTS
9'2"
2'8½"
6"x¾" SKIRTING
7"x2" PLOUGHED AND TONGUED FLOORING.
GLAZED DOOR
"A"
1¼"x⅝" PLANTED BEAD
3½"
PLAN OF ANGLE AND INTERMEDIATE POSTS
9"
SECTION THROUGH SIDE PARTITION.
SCALE OF INCHES.
12 9 6 3 0 6 12.
10'6"
7'0"
3'8½"

has been adopted suitable for a longer screen where continuation of the rails would cause lack of rigidity and thus call for the vertical members throughout to be continuous, if support at the head could be satisfactorily obtained.

There is also a special architectural value in the unbroken lines of the vertical members. On the other hand, there is greater difficulty of construction.

Plain, square rebated framing is employed throughout, the rebates being 2⅝″ wide × ⅝″ deep; an exception is made at the angle posts where the fillings are grooved in and slightly bevelled to get them in position, as shown in plan at A.

The posts are housed ½″ into the floor and the framing jointed by single tenons in frames 2½″ to 3″ thick, but advisably with double tenons if 3½″ or over.

416. Joint at head of angle post. A good method of connecting the angle post to the two head rails is to mitre the latter, cross tongue the joint—or dowel it—and draw close by a handrail bolt, as shown at B and C in detail No. 129. The head of the post is stub-tenoned and the joint secured from lifting by screws or nails. Another method of making the connection is to make a rebated mitre dovetail between the heads and draw bolt the angle to the post through the centre of the dovetail tenon. This method requires that the dovetail should be glued and cramped and allowed to set before being bolted down.

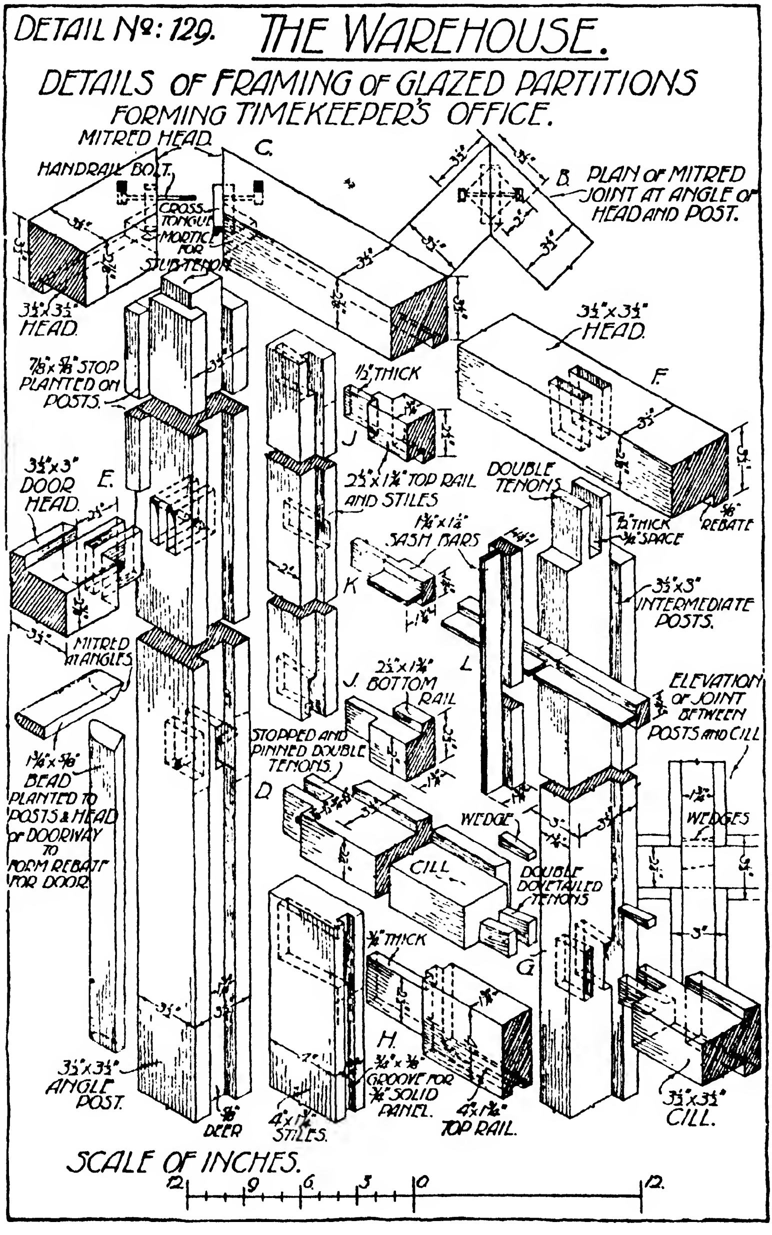
417. Joint between angle post and cill. The joints at D and E show the method adopted for connecting the cill and transome to the angle post. To avoid the tenons showing on the face of the post, they are shortened and fitted into stopped mortices, the joint being held secure by a ⅜″ hardwood pin.

Where two such rails join the post at the same level, the inner tenons would intersect, they are therefore mitred together and glued on insertion. The pin would only be thoroughly effective on the outer tenon.

Tenons to wall posts are similar to the rest but passed through the posts and wedged in the ordinary way, similar to the intermediate post and head joint at F.

418. Joint between rails and intermediate posts. The difficulty with these joints is to make them secure against withdrawal on inserting the filling panels. If short, half way tenons are used and the panels are the least tight the shoulders are forced away, and any other disturbance of the framework has a similar effect.

To overcome this difficulty the pairs of tenons are made long enough to pass through the post, viz. 1¾″, cut to overlap each other


DETAIL No: 129.
THE WAREHOUSE.
DETAILS OF FRAMING OF GLAZED PARTITIONS
FORMING TIMEKEEPER'S OFFICE.
MITRED HEAD
HANDRAIL BOLT.
CROSS TONGUE
MORTICE FOR STUB TENON
C.
B. PLAN OF MITRED JOINT AT ANGLE OF HEAD AND POST.
3½"x3½" HEAD
7/8"x5/8" STOP PLANTED ON POSTS.
1½" THICK
J.
2½"x1¾" TOP RAIL AND STILES
3½"x3½" HEAD
F.
DOUBLE TENONS
½" THICK ½" SPACE
5/8" REBATE
3½"x3" DOOR HEAD
E.
1¾"x1¼" SASH BARS
K.
3½"x3" INTERMEDIATE POSTS.
MITRED AT ANGLES
2½"x1¾" BOTTOM RAIL
J.
L.
ELEVATION OF JOINT BETWEEN POSTS AND CILL
1¼"x5/8" BEAD PLANTED TO POSTS & HEAD OF DOORWAY TO FORM REBATE FOR DOOR
STOPPED AND PINNED DOUBLE TENONS.
D.
WEDGE
WEDGES
CILL
DOUBLE DOVETAILED TENONS
G.
½" THICK
H.
¼"x¼" GROOVE FOR ½" SOLID PANEL.
4"x1¾" TOP RAIL.
3½"x3½" ANGLE POST.
5/8" DEEP
4"x1¾" STILES.
3½"x3½" CILL.
SCALE OF INCHES.
12 9 6 3 0 12

as dovetail tenons, as at G, and inserted by making the mortice longer to allow them to pass into position. The joints are glued and a wedge over each pair brings them close and holds them until the glue is set. These joints must be cramped close at the shoulders before wedging or the object of the joint is defeated.

419. Panelled dado framing and skirting. The dado has $\frac{5}{8}''$ panels in $1\frac{3}{4}''$ framing with plain and square edges, and is jointed as shown at H.

A $3'' \times 1\frac{3}{4}''$ extra rail upon which the skirting is fixed near the base, is framed in below the visible bottom rail. There are two skirting boards both $6'' \times \frac{3}{4}''$, cut in short lengths between the posts. The outer one is deeply chamfered, while the inner one is rounded to mitre with the planted fixing moulds, shown in the various sections of the framing.

420. Sashes to upper portion of screen. The sashes are also $1\frac{3}{4}''$ thick with $2\frac{1}{2}''$ broad framing and $1\frac{1}{4}''$ sash bars.

The outer angles are plain and square and the joints between the members made as shown at J, K and L.

The sash bars in this case are halved together, which is a simple method for square bars.

All rebates are $1''$ wide $\times \frac{7}{16}''$ deep, leaving the tongue of the sash bars $\frac{3}{8}''$ thick.

The proportions of the glazed panes should again be noted. The door is glazed above the lock rail and divided into nine panes to harmonise with the rest of the work.

421. Ceiling of office. Ceiling joists, $4'' \times 2''$, are placed at $18''$ centres and cogged upon the head rails of the partitions.

The $\frac{7}{8}''$ cover boarding is allowed to overhang $2\frac{3}{8}''$ past the face of the partition and shaped to a flat nosing; below this is placed a $4\frac{1}{2}'' \times 1''$ moulded fascia board, and a $1\frac{1}{4}'' \times 1''$ cavetto mould beneath the nosing produces a corniced effect.

At the front of the office where the cover boards, if continued, would show end grain, a return nosing is tongued to their ends and mitred at the angles; a packing piece is laid upon the head for securing the nosing and fascia.

The ceiling boards are of beaded matching nailed to the joists and the angle of intersection with the head covered by a $1\frac{1}{4}'' \times 1''$ cavetto mould mitred round the interior.

Kitchen Fittings

It is usual to provide some form of storage in kitchens for crockery, pans, etc.

In the South of England a fitting known as a kitchen dresser is most used, while in the North of England it is more usual to employ

a combination of drawers and cupboard, especially if placed in a room to be used as a kitchen and living room.

422. Kitchen dresser. This fitting provides for the open storage of plates and dishes, pots and pans and the closed storage of kitchen odds and ends. Though the fitting is convenient it is fully exposed to dust and dirt.

It consists of a framed table with a solid top and a series of drawers immediately below it. Near the floor is provided an unenclosed pot-board upon framed bearers. Above the table is an open plate-rack with a series of grooved shelves to receive plates and dishes which rest in an inclined position against the wall or boarded back. The fitting is shown in perspective in detail No. 130, and may be improved by completely enclosing the lower part to form a cupboard.

423. Construction of dresser. The general construction of the dresser may be gathered from the vertical section and two half plans in the detail.

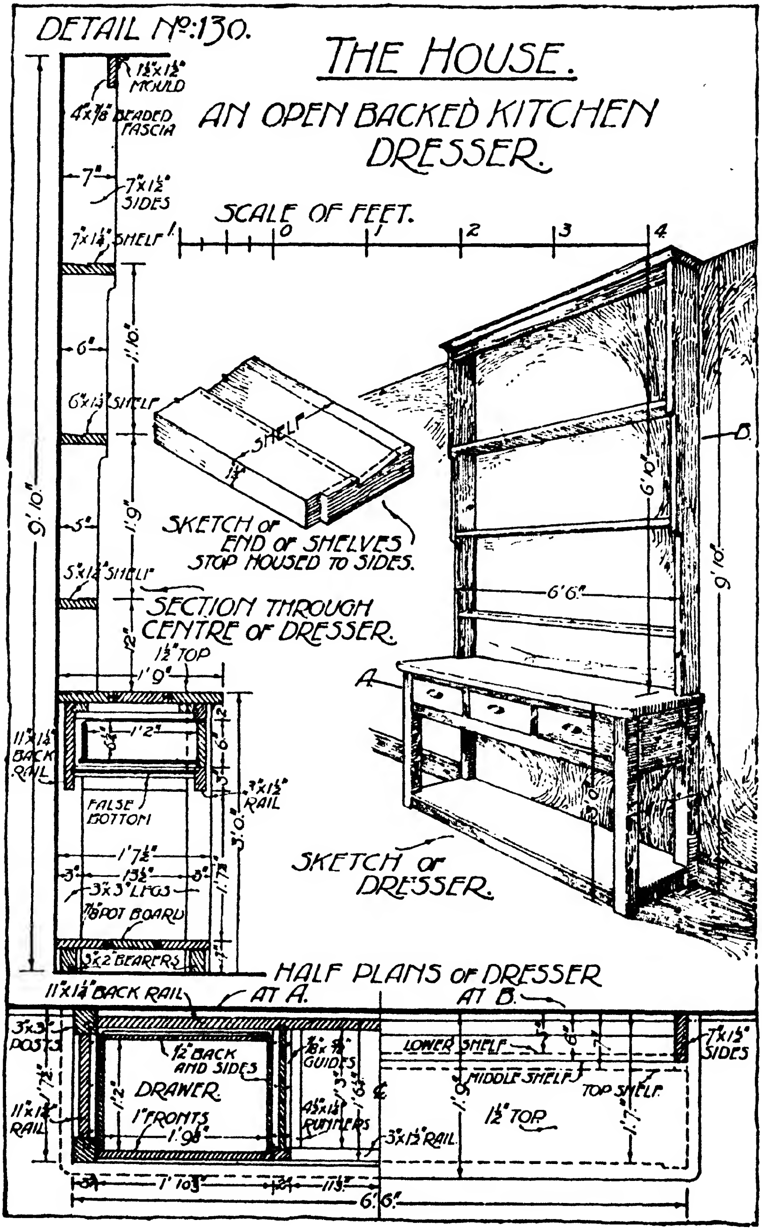
The lower part consists of four 3″ square plain legs, framed together by 3″ × 2″ bearers at the floor, with 11″ × 1¼″ back and end rails at the top end; 3″ × 1½″ and 2″ × 1½″ drawer rails are used, with 1½″ × 1½″ muntins between the drawers. All the joints are made with barefaced tenons as in detail No. 131 at A, mitred together within the mortice where two tenons intersect.

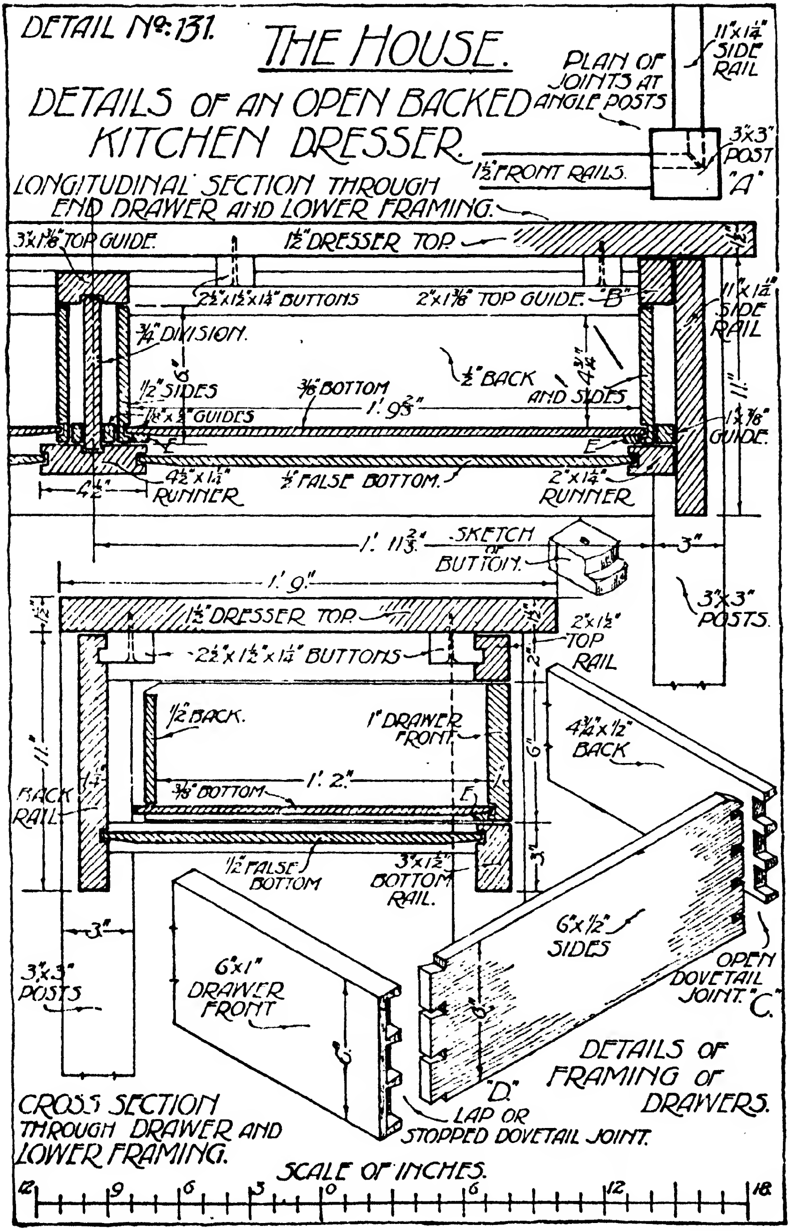
The top is a jointed piece of good yellow deal 1½″ thick or of 1¼″ sycamore, overhanging 1½″, and secured to the top edges of the frame by tongued hardwood buttons which engage in grooves specially prepared. The buttons are screwed to the top by single screws and are rotated into position; they should clasp the top tightly downwards but allow it to expand and contract freely in width. This is a necessary precaution to prevent the splitting of all wide pieces similarly employed; they should never be rigidly fixed by nails or screws.

Other methods are available besides the wood buttons referred to.

The pot board might be similarly prepared and fixed, but as this requires to be notched within the legs and cannot move out of position, it need only be lightly nailed to the end bearers.

424. Preparation for drawers. The drawers are carried on 1¾″ × 1¼″ runners at the ends and intermediately upon 4″ × 1¼″ runners; the end pieces are tongued to the front and back rails into the panel grooves and also screwed to the framing, while the intermediates are kept in position by the panelled bottoms and are also glued at the tongues. The bottom panels are often called "false bottoms" and are intended to prevent thin articles slipping over


DETAIL No:130.
THE HOUSE.
AN OPEN BACKED KITCHEN DRESSER.
SCALE OF FEET.
SKETCH OF END OF SHELVES STOP HOUSED TO SIDES.
SHELF
SECTION THROUGH CENTRE OF DRESSER.
SKETCH OF DRESSER.
HALF PLANS OF DRESSER AT A. AT B.
1½"x1½" MOULD
4"x⅞" BEADED FASCIA
7"x1½" SIDES
7"x1¼" SHELF
6"x1¼" SHELF
5"x1¼" SHELF
1½" TOP
11"x1¼" BACK RAIL
FALSE BOTTOM
3"x1½" RAIL
3"x3" LEGS
⅞" POT BOARD
3"x2" BEARERS
3"x3" POSTS
11"x1¼" RAIL
½" BACK AND SIDES
DRAWER
1" FRONTS
⅞"x⅞" GUIDES
4½"x1½" RUNNERS
3"x1½" RAIL
LOWER SHELF
MIDDLE SHELF
TOP SHELF
7"x1½" SIDES
9'10"
6'10"
6'6"
3'0"
1'9"
11'10"
1'2"
1'7½"
13½"
1'98"
7'10½"


DETAIL Nº 131.
THE HOUSE.
DETAILS OF AN OPEN BACKED KITCHEN DRESSER.
PLAN OF JOINTS AT ANGLE POSTS
11"x1¼" SIDE RAIL
3"x3" POST "A"
1½" FRONT RAILS.
LONGITUDINAL SECTION THROUGH END DRAWER AND LOWER FRAMING.
1½" DRESSER TOP
2½"x1½"x1¼" BUTTONS
2"x1⅜" TOP GUIDE "B"
¾" DIVISION.
½" SIDES
⅜" BOTTOM
½" BACK AND SIDES
1⅜" GUIDE.
½" FALSE BOTTOM.
4½"x1¼" RUNNER
2"x1¼" RUNNER
SKETCH OF BUTTON.
3"x3" POSTS.
1½" DRESSER TOP
2"x1½" TOP RAIL
½" BACK.
1" DRAWER FRONT.
⅜" BOTTOM
BACK RAIL
½" FALSE BOTTOM
3"x1½" BOTTOM RAIL.
4¾"x½" BACK
6"x½" SIDES
OPEN DOVETAIL JOINT "C".
6"x1" DRAWER FRONT
3"x3" POSTS
"D" LAP OR STOPPED DOVETAIL JOINT.
DETAILS OF FRAMING OF DRAWERS.
CROSS SECTION THROUGH DRAWER AND LOWER FRAMING.
SCALE OF INCHES.

the back of the drawer and falling on to the pot board below. Drawers may also be divided vertically in first class work, as shown in plan on the left of detail No. 130 at the bottom.

To prevent the drawers moving sidewise, guides are required at the sides, and to prevent drawers lifting at the back when pulled out more than half their depth, top guides or "kicking pieces" are required as at B in detail No. 131.

425. Construction of drawers. Drawers of moderate size are framed from $\frac{1}{2}''$ or $\frac{5}{8}''$ material for the sides and 1″ or upwards for the fronts, while the bottoms may be $\frac{3}{8}''$ or more, unless made from $\frac{3}{16}''$ or $\frac{1}{4}''$ plywood.

Drawers are usually pin dovetailed at the angles, executed either by hand or by machine. Open dovetails are employable at the back angles, as at C, detail No. 131, but the front dovetails must usually be hidden from view when the drawer is closed.

For this purpose the form of joint shown at D is employed, where a thin piece of the front continues to the end, forming a lap or stop to the side dovetails. The back is usually made shallower than the sides both at top and bottom.

The back of the drawer is kept up $\frac{3}{4}''$ or $\frac{7}{8}''$, so that the bottom can be slipped below it into grooves in the sides and front; it is then nailed or screwed to the back from below and the angles are blocked from below, as shown at E.

The top edge of the back need only be kept down when there is a difficulty for the air to escape from the back of the drawer as it is being closed.

Dovetails, in all cases, should be fairly small and with very little taper and should be closely spaced to allow of perfectly secure glued joints. They must also fit closely, and hold in position when fitted together dry. The material must be dry and well seasoned, and American yellow pine is the only acceptable soft wood timber for the purpose.

426. Crockery rack. The crockery rack is a simple structure made with shaped ends arranged to accommodate shelves of different widths. In the example of detail No. 130 the shelves vary from 5″ to 7″ wide by $1\frac{1}{4}''$ thick.

The sides are stop notched into the top of the table and the shelves similarly notched into the sides, all being nailed together. Each shelf is bevel rebated to form a guard or stop for plates and dishes. The joint and sectional form are shown in the isometric sketch.

To obtain a finish at the ceiling a $4'' \times \frac{7}{8}''$ beaded fascia is fixed between the ends by tongues and nails and a $1\frac{1}{2}'' \times 1\frac{1}{2}''$ cavetto mould gives a light corniced appearance to the whole.

Kitchen Cupboard Fittings

427. Detail No. 132 gives a perspective view of a combined fitting consisting of a nest of drawers 3′ 3″ high surmounted by a cupboard and open space, the former being continued to the ceiling. Such fittings are most usually applied in recesses at the sides of fireplaces, the drawers projecting into the room beyond the chimney breast while the cupboard is much shallower and therefore sunk within the recess.

The fitting illustrated is arranged to fill a recess in the kitchen of the house; its width is 4′ 0¾″ and its depth 1′ 6″. The height from floor to ceiling is 9′ 10″.

428. Construction of nest of drawers. The nest of drawers consists of two long and two short units arranged in three tiers and enclosed in a frame. The carcase or containing framework is 1′ 9¼″ deep and consists of a front frame 1¼″ thick and a back frame of ⅞″ material, connected from back to front by drawer runners and encased by ½″ match-boarding to prevent vermin from penetrating to the interior.

At the angle which projects in front of the chimney breast a special stile is provided out of 2⅜″ square material with a quadrant external angle to which a ⅞″ side facing is tongued, as shown in the plan and isometric view.

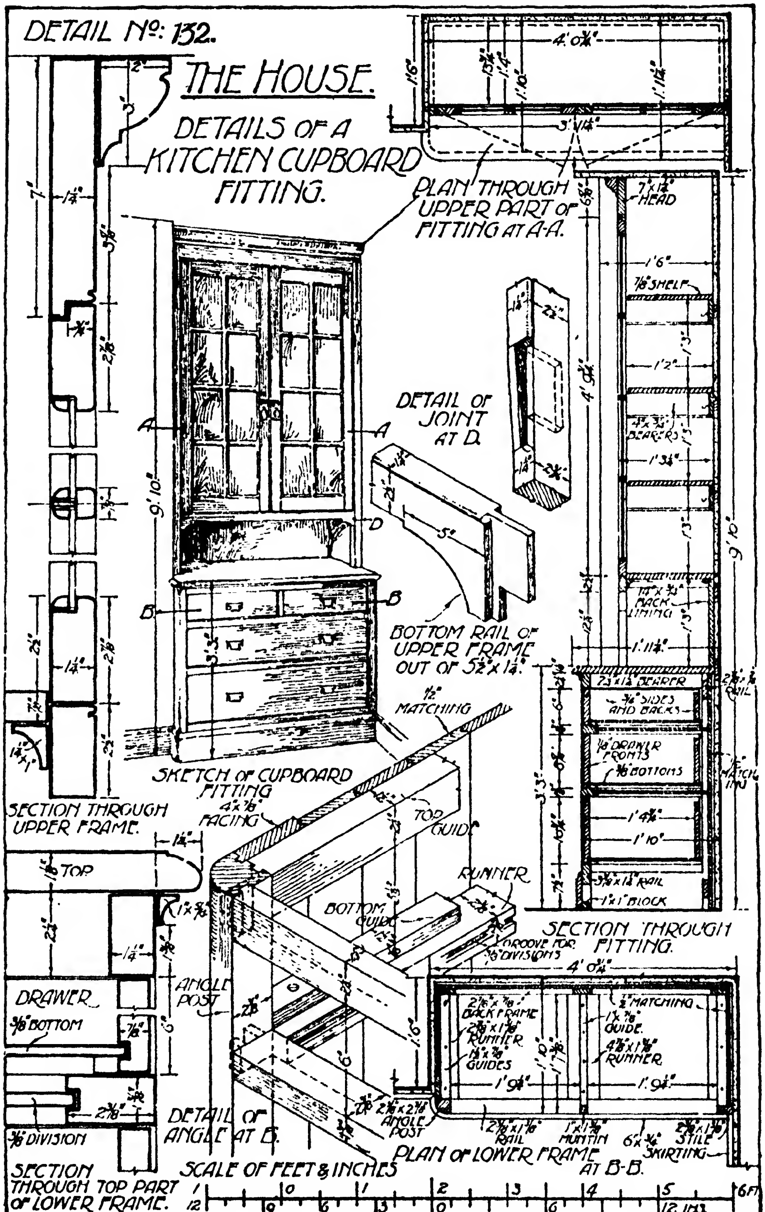
Rails dividing the drawers are 2⅜″ × 1⅜″, laid flat, double tenoned at the ends and grooved on the back edges to receive the false bottoms or divisions. The runners are tongued into these grooves and also notched into the back frame.

Guides are screwed to the runners to confine the drawers sidewise and the top drawers are prevented from lifting by a broad bearer which overlaps the inner edges of the drawers at the centre.

To receive the skirting the bottom rail is kept above the floor and a fixing fillet nailed to the latter to receive the bottom edge. A special piece of quadrant skirting, with the grain horizontal, is employed to return the outline at the projection.

The top is a jointed board 1½″ thick having a moulded edge and a thickness mould below. These mouldings are carried round the quadrant angle and returned to the face of the plaster. Being wide the top is only nailed to its bearers near the front; the back edge can then contract and is prevented from lifting by the back lining of the open space which is tongued into it.

429. Construction of cupboard. The cupboard consists of a rebated frame 1¼″ thick, enclosing a pair of 1¼″ panelled doors; the interior is fitted with ⅞″ shelves, 14″ wide, and an open space


DETAIL No: 132.
THE HOUSE.
DETAILS OF A KITCHEN CUPBOARD FITTING.
PLAN THROUGH UPPER PART OF FITTING AT A-A.
DETAIL OF JOINT AT D.
BOTTOM RAIL OF UPPER FRAME OUT OF 5½" x 1¼".
SKETCH OF CUPBOARD FITTING
SECTION THROUGH UPPER FRAME.
SECTION THROUGH FITTING.
SECTION THROUGH TOP PART OF LOWER FRAME.
DETAIL OF ANGLE AT B.
PLAN OF LOWER FRAME AT B-B.
SCALE OF FEET & INCHES
DRAWER
⅜" BOTTOM
⅜" DIVISION
TOP
ANGLE POST
4" x ⅞" FACING
TOP GUIDE
RUNNER
BOTTOM GUIDE
GROOVE FOR ⅜" DIVISIONS
½" MATCHING
⅞" SHELF
HEAD
BEARERS
BACK LINING
BEARER
SIDES AND BACKS
DRAWER FRONTS
⅜" BOTTOMS
RAIL
BLOCK
BACK FRAME
GUIDES
GUIDE
MUNTIN
STILE
SKIRTING

is left below the bottom rail of the frame, approximately 12″ clear height.

Doors and frame might be rebated on the sides and top to keep out dust (though in this case they are left with plain joints at the hanging edges) and an equivalent rebate formed at the bottom by allowing the lower shelf to stand above the frame; see vertical section and plan, detail No. 132.

A 7″ deep top rail is used in the frame to give a wide fascia while the stiles are only $2\frac{1}{2}''$ wide and the bottom rail shaped out of $5\frac{1}{2}''$ stuff. As the stiles of the frame are carried down to form margins to the open space, a special bevelled shoulder is required at the joint of stile and rail, as shown at D; this accommodates the mitre of the bead and allows a square edge to be formed on the continued piece of the stile.

The interior of the cupboard is plastered to grounds which are shown in plan, these latter providing also for the fixing of the frame at the edges.

Under each shelf is a $4'' \times \frac{3}{4}''$ pin rail to receive cup hooks, these rails being fixed to the wall upon $2'' \times \frac{3}{4}''$ bevelled grounds run horizontally across back and end walls.

The open space is lined with $14'' \times \frac{3}{4}''$ side and back linings which are tongued at the base and finished at the top edges by a cavetto angle mould nailed to the sides. A light wooden cornice mould is used to finish the ceiling angle, assuming that a plaster cornice is not intended.

The cupboard doors are hinged folding, with the knuckles of the hinges coinciding with the edge beads on the frame. These doors do not close against the shelves but against the rebates at top and bottom edges.

430. Wardrobes and kitchen storage fittings should form part of the permanent equipment of all modern houses. If well designed and placed they are much more convenient and efficient than loose furniture, which may have to be provided by the occupier in the absence of permanent fittings.

CHAPTER TWENTY

PLASTERING, AND WALL AND FLOOR TILING

431. Plasterers' work. The work of the plasterer chiefly consists of applying plain and decorative surface coverings of adhesive material over brick, stone, concrete, and wood structures with a view of obtaining a satisfactory finish and otherwise improving the architectural character of both interior and exterior work in an economical manner.

While in monumental buildings interior surface finish is commonly obtained by the wrought or prepared surfaces of the building material, it is inexpedient to apply this procedure to domestic buildings on the grounds of unsuitability and expense, and also the difficulty of applying and renewing decorations.

Work executed in plaster is jointless, clean and sanitary, easily decorated and may be placed upon an inexpensive groundwork of unwrought materials.

The plasterer is, in many parts of the country, also called upon to lay wall and floor tiling, plastic floor finishes, tile casings to steel beams and work of a similar character where lime, cement or plaster compounds or adhesives are employed.

432. Plastering and the materials employed. Plastering consists of covering the surfaces of walls, partitions and ceilings with coats of adhesive plaster and also of producing any ornamentation in the nature of cornices, strings, angle moulds, marginal moulds, and artistic decorations in plastic material.

The materials used by the plasterer for these purposes are dealt with in the Chapter on Materials, and are only referred to very briefly here.

The plasterer employs lime, hair, sand, portland cement, plaster of Paris, Keene's cement and many special or patent plasters.

For internal work on large surfaces, pure lime plaster is employed. Portland cement is used for backings to moulds and cornices and to cover internal positions liable to damp, such as sculleries and wash-houses; it is also employed for all external work. Plaster of Paris is used with lime putty for running moulds and cornices, and for mixing with lime plaster to induce rapid setting. Keene's and other patent cements are preparations of plaster employed for sharp angles, marginal moulds, cornices, etc., and plain work where a fine, hard and durable finish is desired.

INTERNAL WORK

433. Internal walls and ceiling. Internal walls and ceilings are usually covered with plaster made from rich lime, washed sand and a quantity of hair for the first coats.

The lime is well slaked and prepared to avoid lumps of unslaked lime entering the work.

The coverings may be accomplished in two or three coats as desired, the latter being adopted where a first class finish is desired, *e.g.* good class houses and public buildings.

Two-coat work has the first coat of *coarse stuff* and the second of *setting stuff.*

Three-coat work has the first and last coats of the same composition as for two-coat work, with an intermediate coat of either coarse or finer stuff according to the character of the work. A finer and truer finish is possible with three-coat work and its setting coat is selected with this end in view.

434. Adhesion and key of plaster. Plaster must be made to adhere or cling to walls and ceilings. On brick, a *key* is obtained either by leaving the bedding mortar roughly protruding or by raking out the joints, thus affording numerous lines of attachment and support. In partitions and ceilings narrow strips of wood called "laths" are nailed to the framing with $\frac{1}{4}''$ to $\frac{3}{8}''$ spaces between them; or pierced metal sheets may be secured to the framing; the plaster is forced through the spaces, spreads out a little on the back and by virtue of the fibrous character imparted by the addition of hair is supported upon this key. See also paragraph 440.

435. Use of sand and hair in lime plaster. When plaster is prepared for the first coat there are two objects to be accomplished apart from keying to the groundwork.

The first is to ensure that the plaster will dry and set sufficiently hard without undue shrinkage and the second that the whole shall hang together and resist the development of a few large cracks during the amount of shrinkage that must occur.

The use of sand in the ratio of two or two-and-a-half parts of sand to one of pure slaked lime accomplishes the first object by admitting air to the mass of plaster and reducing the fatty lime to a minimum for effective use. The addition of hair assists in the second object by reinforcing or binding the mass, controlling in a measure the development of cracks and bridging across small portions of the groundwork where the adhesion or key may be defective. Hair, well distributed, produces a fibrous coating and thus improves the cohesion of the somewhat thick covering, which is otherwise unsatisfactory.

436. First coat of coarse stuff on walls and ceilings. Coarse stuff is used as a backing on either walls or ceilings. When laid on walls it is termed *rendering*; on partitions and ceilings it is known as the "pricking-up" coat.

The stuff is prepared by compounding one part of slaked and saturated lime with two or more parts of clean gritty sand and the addition of 10 to 12 lbs. of clean ox hair per cu. yard of plaster, more hair being required for ceilings than for walls.

The quantity of sand and the amount of hair vary much with the quality of the work. Some plasterers use ground mortar for rendering and omit hair entirely. The sand varies from one and a half to three parts, to one of lime, depending upon the nature of the two materials and local custom.

Rendering is applied to an average thickness of $\frac{1}{2}''$ and pricking-up to a thickness of $\frac{3}{8}''$ over the laths. This latter point is important, as a thinner cover invariably leaves the outlines of the laths visible and spoils the surface due to the contraction of the plaster and warping of the laths when the wet stuff is laid upon them.

The purpose of the first coat is to reduce the surface of the wall to an approximately vertical plane, cover all joints and crevices thoroughly and form a ground for the finer coats. Rendering plaster should be as soft and moist as is workable to prevent the wall surface absorbing moisture too rapidly and leaving the plaster in a condition not conducive to proper setting. Crystallisation can only take place in the presence of sufficient moisture and adhesion is also improved thereby.

In two-coat work the rendering or pricking-up must be sufficiently true to receive a finishing coat of fairly uniform thickness.

In preparation for the next coat some means of obtaining a key for the latter must be provided. This is usually done while the plaster is soft, by scratching the face of the rendering diagonally in opposite directions with a pointed lath or with a special scratching tool having several points.

437. Second or floating coat on walls and ceilings. The term *floating coat*—commonly applied to the intermediate coat in three-coat work—implies the production of a true surface by the use of an instrument called a float which enables spaces to be filled and worked to a plane surface between bands of carefully plumbed plaster.

Vertical bands of plaster, about 6″ to 9″ wide and $\frac{3}{16}''$ or $\frac{1}{4}''$ thick, are spread at the ends of the surface to be covered and carefully plumbed above the skirting grounds. Other bands or *screeds* are laid vertically between them, these latter being either plumbed or set to straightedges; the intervening spaces are then filled in and floated off with straightedges working upon the partially set

screeds of plaster or with a two-handled pine board called a *Derby float*.

A hand float is also used to consolidate and work up the surface and for laying the succeeding coat. This float is a small board with a shaped handle for use with one hand.

In ceilings the screeds of plaster are run in the more convenient direction across the surface, and finished truly to cornice or other ceiling grounds where these occur.

The material employed for the floating coat varies, but in good work may suitably be composed of one part of fine stuff and one-and-a-half to two parts of washed sand. In some cases a little hair is added, especially if a thicker coat is required.

Fine stuff is rich slaked lime washed through a screen with an excess of water to remove lumps. The lime sediment is left to settle in a tub or pit, surplus water drained off or allowed to evaporate and the lime left to mellow by atmospheric influences for several months.

It should be noted that coarse stuff is also used for floating but it is not satisfactory to the workman unless a finer sand be employed than is usual for builders' mortar.

The floating coat is keyed for the reception of the setting coat by scratching with a broom.

438. Setting coats. The setting or finishing coat does not exceed $\frac{1}{8}''$ thick and is often thinner. In some parts of the country it is known as *skimming*.

The nature of this coat depends on the kind of finish required, whether hard set and gritty or softer and smooth. The former finish is most suitable for distempering or other dead surface resembling a matt finish in painting. For painting or papering upon, the smoother surface is preferable.

Hard finish. When the broomed surface of the undercoat is set and dry, the face is wetted and a setting coat of fine stuff and sand is applied with a hand float or laying trowel.

The fine stuff alone would not set hard because its fatty nature prevents the penetration of air, hence a quantity of fairly fine clean sand is added in the ratio of one-and-a-half to two parts of sand to one of fine stuff. The nature of the finished surface depends upon the skill of the plasterer. It should be gritty, fairly absorptive, with a uniform texture which assists in the even distribution of the decorative colour.

Softer finish. If a smooth non-gritty surface is desired much less sand must be used. A common finish of this kind is obtained by using two parts of lime to one of sand which preserves much of the fattiness of the material and enables it to be worked freely and

smoothly and trowelled to a high finish. This preparation and finish is commonly known as trowelled stucco.

Great care should be taken that the undercoat is thoroughly set before the finishing coat is applied so that there is no great shrinkage of the former after the work is completed, which would cause considerable cracking of the face. Undercoats must be well wetted, however, so that the moisture necessary for the crystallisation of the later coat is not absorbed.

439. Plasterers' putty. The lime used in the last-mentioned setting coat is prepared somewhat similarly to fine stuff, but is refined by washing it through a very fine *hair* sieve. Thus, in addition to removing small lumps of unslaked lime, the grit and impurities are screened out, leaving a perfect lime paste. This is known as lime putty or plasterers' putty.

In some cases a skimming of putty is used neat as the finishing coat, to obtain a fine finish. As lime alone will only harden on the surface the coat must be as thin as possible. Any faults in preparation or workmanship may cause this thin coating to crack and peel away.

440. Lathing. The term is applied to any slotted or perforated groundwork intended to offer a key to plaster, and may be formed by laths of wood, spaced with narrow intervals between, to allow the plaster to squeeze through the openings and spread slightly on the back of the lathing; this gives a "key" or hold, which is sufficient to support the plaster until set.

The maximum spacing of wooden laths is $\frac{3}{8}''$ clear, and the allowable width of any member to which they are nailed is a maximum of 2", otherwise the key of the plaster would be unduly interrupted at the crossing of such members.

End-joints between laths should be butted, not lapped, and should not occur in one continuous line, across a ceiling or partition, because shrinkage of materials and vibration of the structure may result in a crack localised along the line of the joint.

Laths must be soundly fixed and are usually secured by "cut" clout nails or by "round wire" clout nails.

Wood lathing is applied in details Nos. 66 and 133. For description of wood and metal lathing see the Chapter on Materials.

441. Counter-lathing. When plaster is to be attached where the key is interrupted seriously on wood surfaces, or where no key is provided, the surface laths may be packed away by other laths nailed crosswise on the surface at 12" intervals. This is known as counter-lathing and is shown in detail No. 135 at E. In cheap work on narrow surfaces or where counter-lathing cannot be done key

is obtained by studding the surface with clout headed nails protruding from the surface but allowing for a $\frac{3}{8}''$ cover of plaster.

442. Metal lathing. In much modern work metal lathing of various kinds is employed. It is prepared from sheets of thin steel which are cut and deformed so as to provide perforations through which the plaster can pass and cling.

For ceilings, partitions and other plain work the sheets of metal are secured to the studs or joists by staples or two-pronged clips. If fixed to projecting steel joists or ceiling bars of steel, special standard clips are provided for attaching the metal lathing to the bars, and these bars to the joists.

Some lathing is made with special stiffening ribs formed in the sheets so that they possess considerable stiffness and only need support and fixing at the ends of the sheets. Hy-rib is an example of this, previously applied in partitions at detail No. 91.

Applications of both wood and metal lathings are shown later in connection with cornices and beam coverings.

443. Gauged plaster. When lime plaster is desired to set quickly, the rate of hardening is increased by mixing plaster of Paris with it. The latter is chiefly sulphate of lime which sets almost immediately when mixed with water. The addition of plaster to lime compounds is known as *gauging*, and for ordinary purposes the ratio of the plaster of Paris to the lime varies from 10 to 25 per cent.

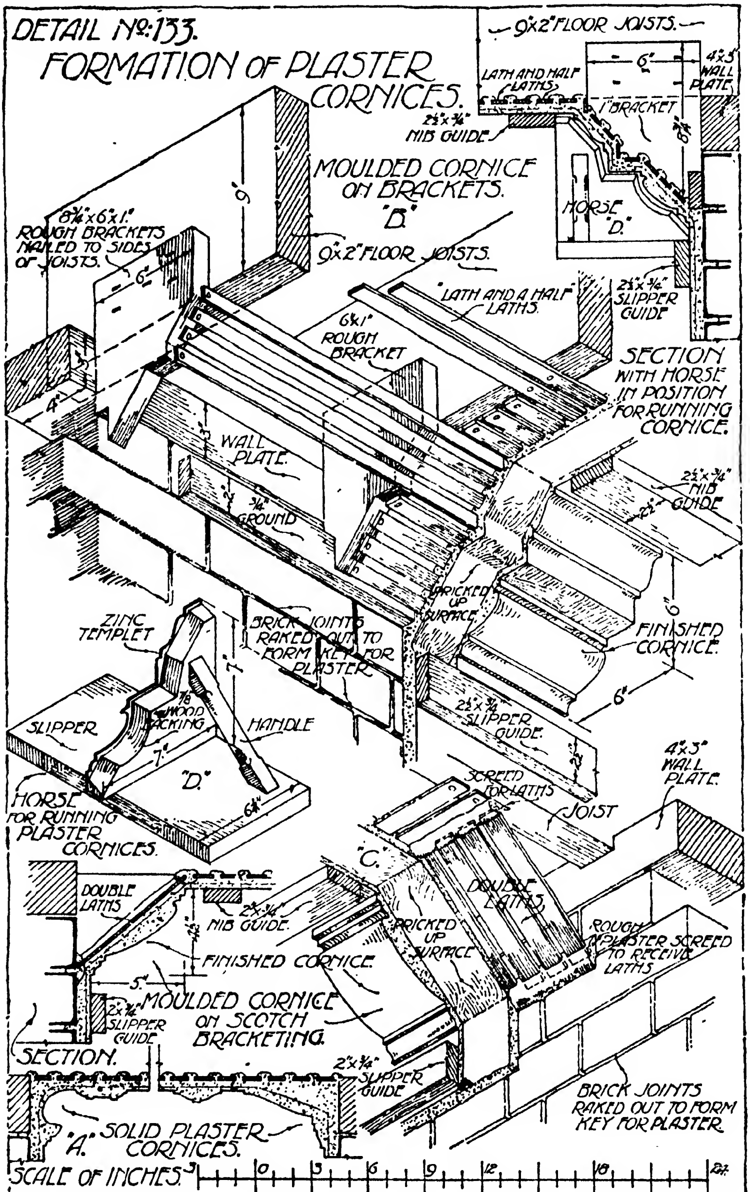
While hardening quickly, gauged plaster takes some considerable time to dry and it should not be distempered nor painted for some weeks after laying, though some wallpapers may be hung upon it within a short time after completion.

Gauged plaster is commonly employed in repair work and alterations where new plaster has to be connected to old work. The plaster of Paris expands in setting and subsequent shrinkage is seldom sufficient to cause a crack or withdrawal at the junctions.

444. Cornices and string moulds. Cornices are usually run in putty and plaster or in special cements, upon a groundwork of gauged coarse stuff or portland cement mortar. In large cornices it may be necessary to use brackets and lathing in order to avoid a large and heavy mass of plaster which it would be inexpedient to employ.

Detail No. 133 shows an ordinary solid plaster cornice at A and also two methods of bracketing for a cornice of larger dimensions at B and C.

Some form of bracketing becomes necessary when the profile of the cornice is such that a large and heavy mass of plaster would result in the angle if treated as a solid cornice.


DETAIL Nº:133.
FORMATION OF PLASTER CORNICES.
MOULDED CORNICE ON BRACKETS. "B"
9"x2" FLOOR JOISTS.
8¾"x6"x1" ROUGH BRACKETS NAILED TO SIDES OF JOISTS.
LATH AND HALF LATHS
2½"x¾" NIB GUIDE
1" BRACKET
4"x3" WALL PLATE
HORSE "D."
2½"x¾" SLIPPER GUIDE
SECTION WITH HORSE IN POSITION FOR RUNNING CORNICE.
"LATH AND A HALF" LATHS.
6"x1" ROUGH BRACKET
WALL PLATE.
¾" GROUND
2½"x¾" NIB GUIDE
PRICKED UP SURFACE.
FINISHED CORNICE.
ZINC TEMPLET
BRICK JOINTS RAKED OUT TO FORM KEY FOR PLASTER.
⅞" WOOD BACKING
SLIPPER
HANDLE
"D."
HORSE FOR RUNNING PLASTER CORNICES.
2½"x¾" SLIPPER GUIDE.
SCREED FOR LATHS
JOIST
4"x3" WALL PLATE.
"C."
DOUBLE LATHS
2"x¾" NIB GUIDE.
FINISHED CORNICE
PRICKED UP SURFACE
DOUBLE LATHS
ROUGH PLASTER SCREED TO RECEIVE LATHS
MOULDED CORNICE ON SCOTCH BRACKETING.
2"x¾" SLIPPER GUIDE
SECTION.
2"x¾" SLIPPER GUIDE
BRICK JOINTS RAKED OUT TO FORM KEY FOR PLASTER.
"A." SOLID PLASTER CORNICES.
SCALE OF INCHES

Ordinary bracketed cornice. The example at B shows the ordinary method in which 1″ brackets are shaped in straight lines to follow roughly the outline of the cornice; these are nailed to the sides of the joists of the upper floor and secured at the lower edge to a $2'' \times \frac{3}{4}''$ rough ground. The edges of the brackets are lathed longitudinally as shown, and pricked-up with a $\frac{3}{8}''$ covering of slightly gauged coarse stuff which is scratched for key before it is set.

When this coat is sufficiently dry the moulded cornice is run with equal quantities of lime putty and plaster of Paris or with a stronger gauging if desired.

The method of running the mould is common to all cornices and is illustrated in the detail. A zinc templet is first cut to the reverse form of the mould, mounted on a roughly shaped wooden bracket with splayed edges so that the zinc clearly projects; the bracket is screwed to a flat wooden slipper and braced by an inclined strut which serves also as a handle and is shaped accordingly; this instrument is called a "horse" and is shown at D. The dimensions are selected so that by running the slipper against two temporary guides, plaster can be spread over the first coat and shaped to the desired outline. These guides are named according to their positions, the "slipper" guide being secured to the vertical surface for the slipper to run against and the "nib" guide to the horizontal surface for the narrow end of the templet to bear against.

Straight lengths of cornice are run in this way and mitred angles then moulded by hand with special tools.

In large cornices special brackets are placed at the mitred angles, and formed with Vee edges to receive and support the ends of the laths.

445. Scotch bracketing to cornice. A very effective and economical method of constructing a hollow cornice is shown at C, and the construction is sufficiently strong for cornices of moderate size.

The wall and ceiling plaster is carried a little beyond the line of junction of wall and cornice. Rough screeds of gauged plaster are then run along the edges in the correct position to receive the ends of short laths, which are stuck into the screeds on the splay and the ends enclosed in the plaster. When set the groundwork of gauged coarse stuff is laid, the finishing coats trowelled on to the wall and ceiling and finally the plaster cornice run as described in the preceding paragraph by the aid of a horse and guides.

These hollow cornices do not crack and depreciate through shrinkage as in the case of solid backed cornices.

446. Cornices on metal lathing. When cornices are to be run against concrete floors and beam casings and to be of sufficient size for hollow construction, they may be supported as shown in detail

No. 134 as applied to the office ceiling of the warehouse. In this case metal lathing is supported by wiring to iron brackets; these are made of $\frac{3}{4}'' \times \frac{3}{8}''$ flat bar with fanged ends which are housed into the concrete or tucked into joints at the ends and plugged with neat cement or plaster of Paris.

The inclined surface is pricked-up with gauged plaster, or if Keene's or other patent cement is to be used, with portland cement mortar, in the ratio of one of cement to two of sand.

The cornice is then run and finished in the usual way.

447. Fibrous plaster cornices. Cornices are in some cases formed in plaster of Paris on a background of canvas and wood, commonly called "stick and rag" work.

They are fixed by screwing to rough grounds and the angles are cut and mitred and made good after fixing.

Such castings involving ornamental bands are often applied to plain run plaster cornices, preparation being made in the profiles of such cornices to receive them.

448. Use of patent plasters or cements. There are several preparations in general use for good plastering known variously as plasterers' cements, patent plasters and hard plasters.

Most of them are specially prepared from calcined gypsum (plaster of Paris) with the addition of substances which give them some desirable quality such as hardness and semi-transparency, fattiness and ease of working, and sharpness of outline in moulds and angles.

We cannot deal exhaustively with the applications of these, but refer the student to further notes in the Chapter on Materials.

The better known varieties are Keene's, Parian, and Martin's cements, Sirapite, adamant and Selenitic plasters.

449. Advantages and defects of hard plasters. The chief advantage is speedy setting and drying. Thus, two-coat work can be quickly and satisfactorily carried out on walls and ceilings if these are fairly true.

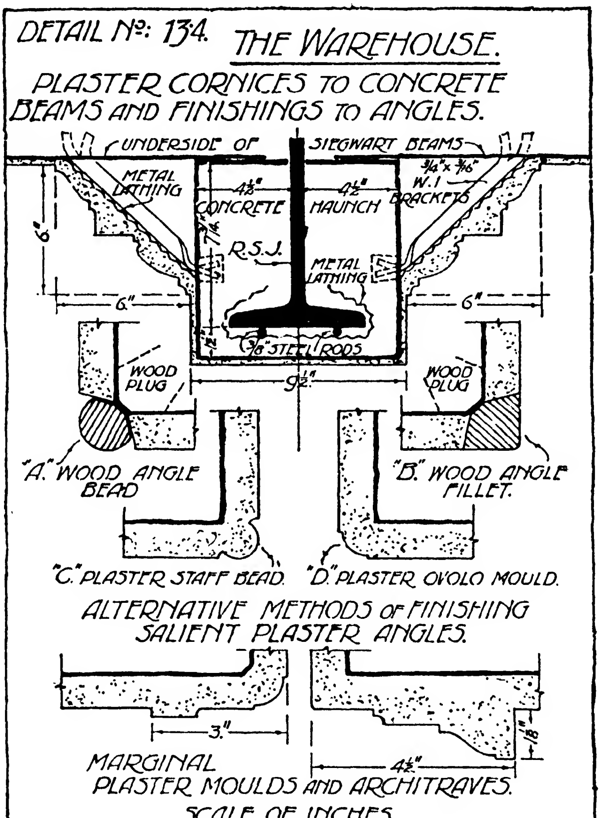
The first coat is usually compounded of sand and patent plaster, with occasionally a little lime added, and the finishing coat of neat plaster, making a thickness of about $\frac{1}{2}''$.

Should the walls be irregular a first or rendering coat of rough material is required and portland cement is the best matrix. Some patent plasters must not be used with lime nor be placed on a backing of lime plaster.

A serious defect of some hard plasters, when worked to a highly finished surface and employed in domestic buildings, is that moisture readily condenses on the face. Lime plaster and portland cement

do not cause this trouble, being more absorptive and not susceptible of the same high surface finish.

450. Angles and marginal moulds. In ordinary work, vertical angles are formed in wood as being preferable to their formation in



ordinary lime plaster, but it is better to run all external angles in hard plaster which preserves their sharpness where desired or allows a durable moulding to be formed should this be preferred.

Various methods of finishing salient angles to plastered walls are shown in detail No. 134.

At A is the ordinary wooden angle bead which is secured to plugs in the horizontal joints of the wall.

The angle of the brickwork is cut away to give a bed for the flat back of the bead. In common work smaller beads are employed and the plugs project to receive them. The edges should be bevelled as shown to provide some key for the plaster, and the edges of the latter may be hollowed if desired, in front of the keyed portion, similar to the section at C.

The section B shows a square or sharp angled bead with the arris slightly rounded. It is a much better form than the round bead for rooms which are to be papered.

Plaster angles are shown at C and D suitable for application to the windows of the warehouse, and are intended to be worked in Keene's cement upon a backing of portland cement. The immediate angle is left uncovered for a width of 2″ on each side when rendering the wall in ordinary lime plaster, the adjacent surfaces being plumbed and squared to enable the angle to be truly formed. When dry a portland cement backing with one of cement and two of sand is run along the angle to bring it roughly level with the rendering and following the mould in plan. Thin screeds of wood are then attached on each side of the angle and the floating coat of wall plaster laid flush with these and allowed to dry; the setting coat is then laid and the strips removed. As soon as the setting plaster has hardened, the mould—or sharp corner—is run in Keene's cement parallel to the finished wall faces.

Marginal moulds or architraves such as those shown at the foot of the detail are run in a similar manner, a small horsed templet being used for the reversed outline, with the necessary guides.

External Work

451. External plastering on brick or stone. External walls are often constructed of good ordinary bricks or of rubble stone and afterwards rendered with cement plaster and finished in one of several ways. In some districts plinths, cills, strings and cornices are formed with rough corbelling or offsets, and run in cement. The object in view may be either to imitate stonework or to obtain resistance to the weather.

The preparation which can be recommended in modern urban work as a cementing material for external purposes is portland cement plaster or stucco; the ratio of cement to sand should be about *one* to *three* for the groundwork, and the fining or surfacing coat *one* to *two* or *two* to *three*, employing a finer sand.

To obtain a key, joints should be raked out to a depth of $\frac{5}{8}''$, brushed clean, and the entire surface well moistened. True surfaces are obtained by the process of floating, horizontal screeds of plaster being first run between vertical plumb rods or straightedges; the

horizontal screeds are next connected by vertical ones at convenient intervals not exceeding 8 ft. and when these are sufficiently firm the panels between the screeds are filled and floated off flush and left for a few days.

To key the finishing coat the surface of the groundwork must be roughed and it should be moistened on the face before applying the fining material. Fining material should be gritty enough to work up to a surface having a satisfactory texture; and there should be no gloss on the surface of external plaster.

Rendering varies in thickness from $\frac{3}{8}''$ to $\frac{5}{8}''$ and fining averages $\frac{1}{8}''$, making a total thickness of $\frac{1}{2}''$ to $\frac{3}{4}''$.

Moulded work is run with a horse and guides and mitres finished by handwork as described in paragraph 444 for internal plastering. All projections should be well weathered and throated.

Imitation of stonework is not to be recommended, though this is often done by jointing the material of the fining coat before it sets, using a jointing iron, which is pressed in and drawn across the face, as already explained for mortar joints in Vol. I.

452. Thresholds, cills, heads, copings, etc. in plastered work. Instead of constructing these in brick or rough stone and covering them with cement plaster, they are sometimes cast in concrete by the use of special wooden moulds and set in correct position in the structure as required. Care should be taken that the surface finish harmonises with that of the fining coat in the subsequent surface covering for the plain surfaces.

453. Rough cast finish. This refers to the covering of the external wall plaster by a rough material such as small gravel, crushed stone, or coarse sand. It is usually laid as two-coat work, either in portland cement or lime plaster, the first coat being done in the ordinary way and a second but thicker coat applied when the first has set. While the second coat is soft, the rough cast is prepared by mixing the selected material with hot lime or cement grout to a thick paste and flinging it from large trowels upon the face; when set, it forms a protecting coat which is usually preserved by periodical applications of lime whiting, or lime and colour.

454. Pebble dash finish. This is merely a variation of the old form of rough cast work. Its groundwork is of portland cement plaster in two coats and the covering is selected from small pebbles, flints, hard limestone and granite chippings, or white spar. When the second coat is spread the rough covering, say spar, is thrown against the surface, pressed flat and uncovered parts filled by hand.

In good work the pebble dashing should cover all the surface fairly regularly, each unit being half-embedded in the cement groundwork.

FLOOR SURFACES IN CEMENT COMPOUNDS

455. Cement floor finish. Concrete floors are often surfaced by a covering of portland cement and sand. When this is to be done a rough upper surface should be left on the concrete filling. The purpose of this covering is to provide a suitable wearing surface of uniform texture and quality; it may be laid in one or two coats, but one-coat work is best unless the undercoat is laid for levelling-up purposes before the floor concrete is thoroughly set. In any case care must be taken to brush off all rubbish and dust and to moisten thoroughly and cleanse the old surface before applying another coat.

For one-coat work $\frac{3}{4}''$ should be allowed and in two-coat work $1\frac{1}{2}''$ is necessary, the undercoat being of one part portland cement, one-and-a-half parts coarse sand and one-and-a-half parts of small stone chippings, shingle or gravel; the floating or surface coat should have one part cement to one or one-and-a-half parts sand which must not be too fine.

The chief difficulty is to avoid excessive shrinkage and cracks and to ensure adhesion of the coats, while producing a non-slippery surface. Sand assists in preventing shrinkage and produces a rougher face, but an excess of it reduces the adhesion and cohesion of the material.

A thoroughly plastic mixture without excess of water is desirable. It is laid to levels and floated to a true face for both coats and the floating coat should be laid where possible before the undercoat has thoroughly hardened.

In upper floors it is seldom possible to obtain satisfactory conditions to ensure a reliable finish and other types of floor finish become desirable.

In order to avoid unsightly cracks, which commonly occur in cemented floors, the surface may be divided up into sections about 6 ft. square, by soaped wood slips set vertically upon a rough screeding of cement. The edges of the wood slips are set in the plane of the intended floor surface and may then be used to float the covering to position.

When these have set the wood slips are removed and the grooves filled up with asphalte, or with cement grout finished to a Vee joint. Any cracks caused by shrinkage will usually be confined to these joints, which can easily be made good without unsightly patching.

456. Granitic floor finish. For floors sustaining much traffic it is advisable to use granite in the form of fine chippings and coarse sand, instead of ordinary sand. Compounded with portland cement in equal proportions, and well worked to a compact surface, this material is very satisfactory.

Similar floors, possibly with the use of some special cohesive and expert labour, and treated on completion with liquid hardeners, are laid under the name of granolithic floors. They are highly satisfactory if care is taken to render them non-slippery.

To overcome this latter difficulty, especially in stairs and landings for schools and public buildings, gritty preparations such as carborundum, emery, etc. are often compounded with the surfacing material.

457. Terrazzo floors. Terrazzo or "Venetian Mosaic" is the name given to a floor finish in which small irregular shaped coloured pieces of hard stone, marble, etc. are compounded with cement mortar, spread in a $\frac{1}{2}''$ (or thicker) layer over a levelled bed of concrete or floated undercoat, screeded level, allowed to set and then ground, scoured and polished by weighted grit stones, sand and water until the surface is flat and exposes the coloured surfaces of the various coarse materials. By careful selection of material of suitable colours and good cement and workmanship, an excellent, easily cleaned floor is obtained, of a pleasing character.

Such floors may be arranged in regular geometrical patterns or other preconceived outlines by arranging strips of wood, cut to the form required, on the surface of the under coat and of a thickness equal to the finishing coat. The latter is then laid between the strips, allowed to set and the strips removed; the spaces left by their removal are then filled with a compound of a different colour. When set the whole floor can be scoured and polished.

An application of this floor is suggested for the lavatories of the warehouse.

458. Roman mosaic. This consists of the selection and bedding of small cubes of different coloured marbles or tiles upon the previously prepared concrete floor. For simple work the cubes, which are about $\frac{3}{4}''$ each way, are placed by hand into a floating coat of cement mortar, upon the levelled concrete floor, allowed to set, and then polished as described in the previous paragraph. Designs are obtained by temporarily securing the coloured cubes face downwards upon stiff brown paper, this is then placed in position on the floated surface of the floor, and when partially set, the brown paper is damped and removed, irregularities and any plain groundwork filled in by hand, the whole grouted in, and the floor finished by polishing. A similar type of mosaic is also often used as a wall covering.

Floor and Wall Tiling

This is a special branch of builders' work requiring care, expert craftsmanship and an appreciation of colour and artistic arrangement. In many parts of the country tiling is done by the general plasterer.

While designs and the selection of materials and colours are usually made by the architect, considerable variations of tint occur in some classes of tiles and much depends on the craftsman if the best use of them is to be made.

Materials used. The tiles are usually in squares of 3″ to 6″ side though both larger and smaller tiles are available. Marginal tiles, 6″ × 3″ and 6″ × 2″, are also common. The average thickness is $\frac{3}{8}$″ to $\frac{1}{2}$″ and the backs are sunk to give a key for bedding. For kinds of tiles available see Chapter on Materials, paragraphs 688 to 691.

Tiles may be bedded in white plaster, coloured plaster or cement, according to the position, nature of the tiles employed and the strength required.

459. Floor tiling. Tiles are in use for hearths, entrance halls, vestibule floors, sculleries, washhouses, paths and yards.

For external use large thick tiles or paving bricks are used; they must be laid to a reasonable fall and bedded solidly on dry ashes overlying a bed of dry hard well packed rubble or broken brick, or advisably on a bed of rough concrete. In the latter case they should be bedded in good mortar and in either case the edges should be so jointed. Such tiles require to be non-slippery by the nature of the materials, or serrated on the surface if of hard glazed ware.

Tiles for internal floors are suitably 6″ to 12″ square and they should invariably be laid on concrete and bedded in neat cement.

Hearths may be finished with glazed tiles selected to harmonise with any tiling used in the fireplace fitment. They are bedded in portland cement upon a levelled bed of concrete. An allowance of $\frac{3}{4}$″ is usually made for the thickness of tiles and bedding and the hearth is made of such dimensions as will avoid cutting of the tiles. An application of hearth tiling is given in detail No. 24.

Vestibules and entrance halls are laid in the same way as in these latter cases, but often with plain, unglazed, self-coloured tiles in varied tints, shapes and dimensions to form geometrical patterns.

460. Marble tiling. Marble tiles are formed from sawn slabs of selected material and of different colours.

They may be assembled and laid in a similar manner to artificial tiles, but are much more effective; they are of softer texture, translucent in appearance and lack the hardness of outline common to artificial tiles.

They should be laid on a floated surface of portland cement and bedded in Keene's cement or other hard and insoluble plaster which will not stain the tiles. Care is required in laying to avoid marking of the upper surfaces by the bedding mortar.

Like all tiling, these marble tiles must be bedded perfectly solid; any imperfect work will result in cracked tiles and loosening of the fabric.

Marble tiling may be ground and scoured to a level surface if required and polished like Terrazzo.

This type of floor finish is applied in octagonal and square units to the hall floor of the house, as shown in detail No. 45. The units may be alternatively of brown Hopton Wood stone and grey Purbeck marble, or black Derbyshire marble and white Irish or Sicilian marble.

461. Wall tiling. Wall tiling is used for dadoes, sculleries, backs of sanitary fittings and for the entire walls of cooking kitchens, sanitary conveniences and similar positions where hygienic conditions are of first importance.

As in floor tiling a satisfactory backing is necessary and a coat of portland cement mortar forms the best ground. Being vertical, the tiles must be well keyed to the backing and for this purpose many tiles are specially provided with shallow dovetailed nibs or margins, or with continuous dovetailed grooves like terra-cotta floor lintols.

The bedding material may be either portland cement or hard plaster according to the colour of the tiles, but as most sanitary wall tiling is done in glazed white tiles of a selected size, white hard plaster would usually be employed.

Several applications of wall tiling are shown in Vol. III.

Moulded tiles of special width are supplied for plinths and dado capping moulds; their average thickness is usually $\frac{1}{2}''$, the backs being hollow.

Casing of Timber Beams

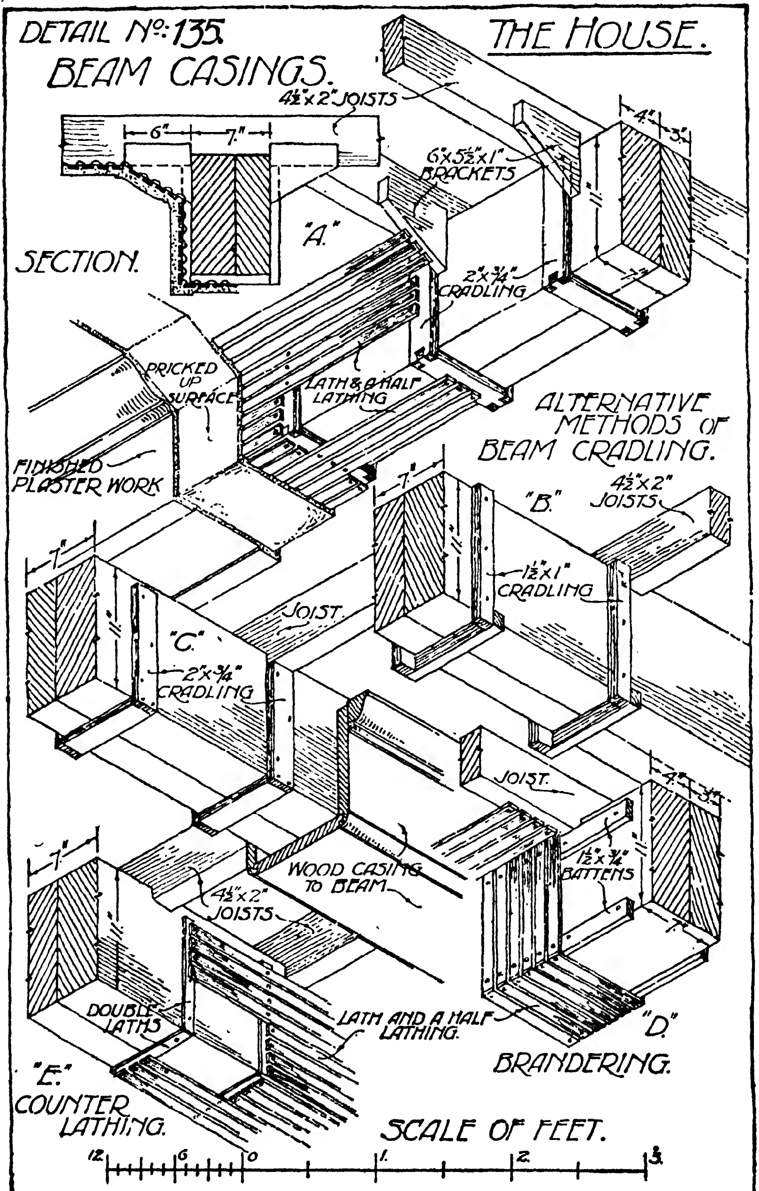
Timber floor beams, such as binders and girders, often require casings which may be of (*a*) plaster, or (*b*) plain or panelled wood.

462. Cradling. Whatever method is used some form of cradling is necessary. In detail No. 135 three methods of "cradling" or "firring" are shown.

At A, $2'' \times \frac{3}{4}''$ strips are dovetailed at the angles and nailed to the beam at about $15''$ centres.

At B, $1\frac{1}{2}'' \times 1''$ vertical strips are nailed to the sides of the beam and similar strips to the sides of these on the soffit of the beam.

In the third example at C, the soffit strips are cut between the vertical strips and nailed through their ends.


DETAIL Nº: 135.
BEAM CASINGS.
THE HOUSE.
4½"x2" JOISTS
6"
7"
SECTION.
6"x5½"x1" BRACKETS
4"
3"
"A"
2"x¾" CRADLING
PRICKED UP SURFACE
LATH & A HALF LATHING
FINISHED PLASTER WORK
ALTERNATIVE METHODS OF BEAM CRADLING.
7"
"B"
4½"x2" JOISTS
1½"x1" CRADLING
"C"
2"x¾" CRADLING
JOIST.
JOIST.
WOOD CASING TO BEAM
4½"x2" JOISTS
1½"x¾" BATTENS
DOUBLE LATHS
LATH AND A HALF LATHING.
"D"
BRANDERING.
"E"
COUNTER LATHING.
SCALE OF FEET.
12
6
0
1.
2.
3.

463. Brandering. In the method shown at D horizontal strips or battens are nailed to the sides of the beam, the lower ones projecting slightly below its soffit; this is known as "brandering" and is a convenient way of packing the laths clear of the beam in order to obtain a "key".

464. Counter-lathing. Counter-lathing, which has previously been referred to, is shown at E, and consists of nailing double laths to the sides and soffit of the beam in a similar way to cradling.

The beams, when so prepared, may be covered either with wood or metal lathing suitable for coating with hard plaster. Panelled soffits are often adopted.

465. Wood casings. If these are to be of painted soft wood, they may be nailed to the cradling, but hardwood casings should be slot-screwed, clearance being allowed at the sides for sliding down upon the soffit piece.

The lower angles are usually moulded and tongued together in a manner which will hide the joint.

CHAPTER TWENTY-ONE

GLAZING AND PAINTING

466. Glazing. The term glazing may refer either to the transparent or semi-transparent panels in windows and sash doors or to the process of securing these in position.

The primary purpose of glazing is to admit light but not necessarily to admit the full strong rays of the sun. In some buildings and parts of buildings the glazing is purposely selected with a view to obscuring partially or dimming the light, either for architectural or domestic reasons.

467. Transparent glazing. Where full transparency is desired, as in ordinary windows, two kinds of glass are available, viz. sheet and plate glass.

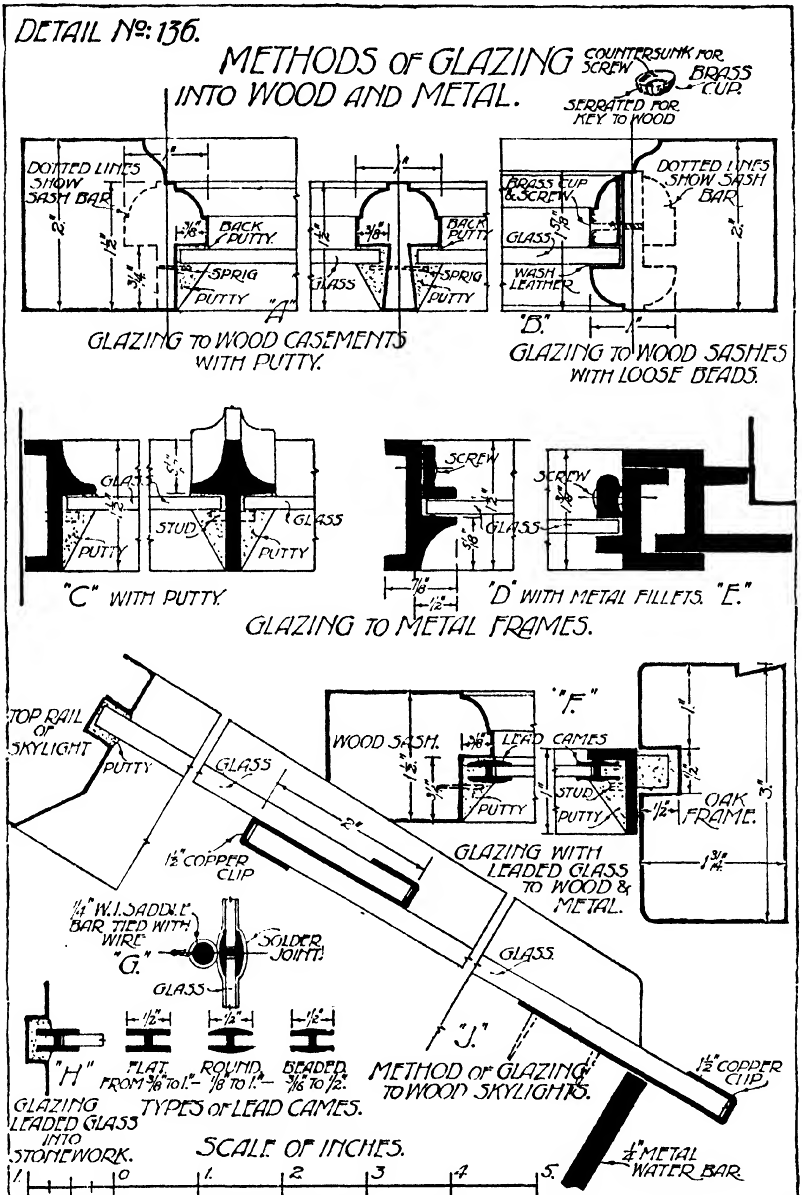
The former is produced by economical processes which result in comparatively thin sheets liable to defects and irregularities of surface, while the latter is of high quality, with true surfaces produced by grinding, is necessarily thicker and stronger and hence more expensive.

468. Sheet glass.[1] This glass is obtainable in thicknesses varying from $\frac{1}{15}''$ to $\frac{1}{8}''$ and having a maximum size of about 4 ft. × 3 ft. It is described and specified by its weight in ozs. per ft. super, the common weights being 15, 21, 26 and 32 ozs.

Most ordinary glazing is done in 26 oz. glass, though 21 oz. is also used for small panes; the former is about $\frac{1}{10}''$ thick. It should be specified to be free from air cavities, cloudy patches and wavy surface.

469. Fixing of sheet glass. Sheet glass is bedded upon a layer of putty placed in the rebate of the frame. This layer is called "back putty", its purpose being to give a solid contact all round the edges and to render the joint watertight; the pane is then further secured by headless steel brads called "sprigs" and the edge overlapping the rebate covered by a neatly bevelled fillet of putty as shown by the section in detail No. 136 at A. In order that putty may adhere, the rebates of the woodwork should be well primed, and if very absorptive they should be brushed over again with thin oil paint and allowed to become tacky. The putty will then adhere, and the oil with which it is mixed will not be absorbed, an occurrence which is very detrimental to the work.

[1] See Chapter on Materials.


DETAIL Nº: 136.
METHODS OF GLAZING INTO WOOD AND METAL.
COUNTERSUNK FOR SCREW
BRASS CUP.
SERRATED FOR KEY TO WOOD
DOTTED LINES SHOW SASH BAR
BACK PUTTY
SPRIG
PUTTY
GLASS
"A"
GLAZING TO WOOD CASEMENTS WITH PUTTY.
BRASS CUP & SCREW
GLASS
WASH LEATHER
DOTTED LINES SHOW SASH BAR
"B."
GLAZING TO WOOD SASHES WITH LOOSE BEADS.
GLASS
STUD
PUTTY
"C" WITH PUTTY.
SCREW
GLASS
"D" WITH METAL FILLETS. "E."
GLAZING TO METAL FRAMES.
TOP RAIL OF SKYLIGHT
PUTTY
GLASS
½" COPPER CLIP
WOOD SASH.
LEAD CAMES
STUD
PUTTY
"F"
OAK FRAME.
GLAZING WITH LEADED GLASS TO WOOD & METAL.
¼" W.I. SADDLE BAR TIED WITH WIRE
SOLDER JOINT
"G."
GLASS
"H"
GLAZING LEADED GLASS INTO STONEWORK.
FLAT. FROM 3/16" TO 1."
ROUND. 1/8" TO 1."
BEADED. 3/16" TO ½."
TYPES OF LEAD CAMES.
"J."
METHOD OF GLAZING TO WOOD SKYLIGHTS.
½" COPPER CLIP
¼" METAL WATER BAR
SCALE OF INCHES.
1 0 1 2 3 4 5

Back putty is trimmed off when the front fillet is somewhat hardened and the latter is painted over to prevent too rapid oxidation of the mixing oil.

The objection to this system of glazing is that the putty has to be cut out for repairs and the woodwork is often damaged in the process.

470. Plate glass. Most of the plate glass used in England is known as British polished plate, being cast, rolled, ground true on the faces and highly polished. It is supplied in definite thicknesses, *e.g.* $\frac{3}{16}''$, $\frac{1}{4}''$, $\frac{3}{8}''$, etc. and is suitable for all first class windows, especially in shop fronts, offices and public buildings where large panes may be required.

Plate glass should be invariably secured in position with moulded wood strips which are mitred round the rebates and nailed or screwed to the framing or sash bars, as shown in the detail at B. Where the strips are wide enough brass cups to receive the screw heads should be employed. In sashes and external doors the glass must also be back puttied as in ordinary glazing to ensure resistance to the weather, but in vestibules, screens and internal doors the panes are preferably bedded on strips of chamois leather to minimise the effects of shock through rough usage.

In shallow rebates with thick glass, the rough edges will usually be seen by reflection unless the edges are obscured. It is advisable to paint the rebate, the edge of the glass and the back edge of the glazing mould with a *dead* black paint.

471. Rough plate and figured rolled plate. Special kinds of plate glass are obtainable, these being cast and rolled but not polished. Plain or slightly wavy rough plate glass is partially obscured and suitable for unimportant positions where a measure of privacy is desired.

If rolled to form embossed patterns the material is known generally as figured rolled plate and also by special names according to the nature of the pattern or variation in the process of production.

For fire-resisting purposes and also for positions where damage is liable to be frequent, wired plate glass, either rough rolled or polished, is made by enclosing a sheet of woven wire mesh within the glass.

Rough plate is fixed by bedding, sprigging and filleting with putty, or by moulds, as described in the previous paragraphs.

472. Obscured glass. Obscured glass is made by removing the conditions of transparency. Smooth faced glass is transparent, but if the surface is partially or wholly ground to produce a rough face it becomes obscured.

The commonest form is called "ground glass", in which the entire surface on one side has been made rough by exposure to a blast of fine sand. If partially ground, in patterns, it is known as "figured glass". It is used for bathrooms, lower panes of windows and screens, and any position where privacy is desired.

Glass obscured by embossed surfaces has largely replaced the ordinary ground glass in modern work, because many of the patterns are so formed as to improve the transmission of light while obscuring the view.

All such glazing as here described should have the smooth face placed on the outside of external doors and windows.

473. Selection of glass for special purposes. A large number of qualities, kinds and patterns of glass are obtainable and the student could only obtain satisfactory information and real knowledge of them by examining samples of those produced by the leading manufacturers and noting the effect of their use in architectural work.

Simple combinations, artistically arranged, should be the aim of the designer and highly coloured glazing of any kind should be avoided except in stained glass windows.

Some of the better known kinds of glass are specially referred to in the Chapter on Materials.

474. Preparation and fixing of loose moulds. The loose moulds referred to in paragraph 470 are also known as glazing moulds, glazing beads or screeds. The term bead is very common and due to the frequent use of a beaded edge to the strip. Great care should be taken in preparing these strips so that the thickness exactly fills the rebate while the width allows accurately for the thickness of glass and bedding, so maintaining the correct setting of the moulded edge in relation to the face of the work.

475. Breakages of glass. Glass is often broken by the twisting of wooden framing in which it is fixed, or by attempting to force it slightly to fit a rebate which is somewhat twisted. The latter condition is overcome by proper bedding when putty glazing is adopted, but in the case of twisted frames, with the glass secured by moulds, it always results in bad work, because the widths of the moulds have to be accommodated by reducing them.

If a frame is prepared free from twist, it will only remain so provided that the material is reasonably straight in the grain and well seasoned.

Doors which are true, must also be truly fitted to their rebates to avoid the breakage of glazed panels, because when slammed into a rebate which is not parallel to the plane of the door when closed,

they are temporarily twisted by the force of the closing door and the strain may cause the panes to snap, especially when employed in large sheets.

476. Glazing into metal casements. Metal casements are usually glazed like wooden sashes, being provided with a rebate, as shown at C, in detail No. 136; the glass is back puttied and secured by smooth pins instead of sprigs. The pins do not touch the glass but are an assistance in providing a hold for the putty fillet.

The sashes should be well primed with oil paint when made and the rebates again painted the day before glazing is to be done. A quick, hard setting, stiff putty must be used as ordinary glaziers' putty will not set hard on the metal.

It is important that the glass should be cut so as to bed in position without touching the metal; contact is liable to produce cracks in the glazing due to vibration and expansion.

Where glazed from the inside of the sash, wooden glazing moulds might be substituted for the putty fillet, countersunk screw pins being provided instead of the plain pins used for putty glazing.

Other methods of securing the glass in metal casements by the use of metal glazing fillets are shown at D and E. In the former a metal glazing angle is set-screwed to the sash and in the latter a metal bead is similarly fixed. In both cases putty bedding is necessary. These methods are advocated for plate glazing and for large casements.

477. Glazing into metal cames. Sheets of glazing are made up into panes of any shape and detailed pattern by enclosing comparatively small pieces of glass in specially prepared bands of lead, called *cames*.

Lead cames are of **H** section when the glass is enclosed, the latter being secured between the pairs of wings on each edge, as shown in detail No. 136 at F. Being flexible, the cames can be opened and closed at will and also bent to any desired line to build up an ornamental design as frequently adopted in stained glass windows.

In forming patterns the cames are fitted neatly together and soldered at their junctions, continuity being given to as many members as possible. The cames are commonly $\frac{1}{4}''$ to $\frac{3}{8}''$ in width, though they are obtainable in some patterns from $\frac{1}{8}''$ to $1''$ wide.

Lead margins are provided wide enough to fill the rebate and to show a marginal band at the sight edge at least equal to half the width of the came. The completed pane is known as a "leaded light".

Ordinary leaded lights require strengthening and supporting if their dimensions are large; this is done by placing metal saddle-bars of round or square section on the inside of the framing, soldering

pieces of copper wire to the back of the cames in suitable positions, and securing them by looping over the bar and twisting the ends together, as illustrated at G.

Putty for bedding leaded lights should be composed of ordinary glaziers' putty with a mixture of red lead and oil, and if loose wood beads are to be used they should also be bedded in putty.

Without the admixutre of red lead the adhesion to the margin of the came is faulty, and the putty does not set hard nor quickly enough for satisfactory results.

Glazing leaded lights into grooved stonework. Leaded lights are often fixed directly into plain grooves cut in the sides of stone jambs and wood frames.

To insert the leaded light the wings of the outer cames—which form the margin—should be bent back in order to clear the sides, when the panel can be slipped into position and the wings straightened out again. The groove is then pointed with mastic cement, as shown at H in the detail.

Leaded lights are sometimes sprung or bent to get them into position, but this always results in troublesome leaks due to straining the cames.

478. Reinforced lead cames. An improved form of came is also in use, which consists of the usual H section reinforced by a light rectangular steel bar enclosed within the lead and having its larger dimension at right angles to the plane of the light.

The cames are slightly larger and heavier but the improvement enables saddle bars to be dispensed with and avoids the concave external surface which is soon caused on the ordinary leaded light by wind pressure, because the lead alone has not sufficient elasticity to regain its normal position after being strained. Reinforced cames are not so easily employed for curved work.

Leaded lights are not suitable for doors, since the constant closing of the door is bound to damage them.

479. Glazing to skylights and other roof lights. In preparing skylights for glazing it is impossible to divide the length of the light by cross bars into suitable dimensions for glazing, hence where the length exceeds that of the sheet of glass, arrangements have to be made for jointing without interfering with the flow of water. This is done by overlapping the sheets, as shown in the detail at J, each portion being bedded solid. In heavy lights where support is required other than the putty and sprigs can supply, copper clips or tingles are bent and inserted as shown in the detail.

An advantage of this arrangement is that condensed moisture can freely escape through the small space between the overlapping portion of the sheets.

In this arrangement it is presumed that the resistance to slip will be transferred to the lower portion of the glazing, hence this should be at least equally secured at the foot by clips fixed to the bottom rail of the frame, as shown at detail No. 124.

PAINTING

480. Preservation and decoration of buildings by surface coverings. Certain portions of buildings require surface treatment in order to preserve the materials of construction, while others are so treated for reasons of sanitation and cleanliness. In either case the treatment presents a legitimate opportunity for decoration which is worthy of careful study on the part of the student of building.

The materials available for use are various coal tar preparations, paint, varnish, enamel, polish, wax and distempers, apart from wallpapers and other types of covering which may be classed as almost purely decorative.

481. Materials requiring preservation. The chief materials requiring preservation are timber and iron.

If exposed to the external atmosphere, soft woods and also most hard woods suffer deterioration from alternations of wet and dry weather and also from changes of temperature.

Iron rapidly oxidises especially in damp atmospheres and more particularly in the forms of wrought iron and steel.

482. Materials requiring sanitary treatment. All internal surfaces of buildings require periodical treatment with a view to rendering them clean and sanitary.

Woodwork; plaster surfaces in walls, ceilings and decorative features; and uncovered hardwood floors come under this heading.

483. Painting. This term is usually applied to the process of spreading surface coatings of colouring and preservative matter, prepared in a fluid condition, and applied with a brush. The preparation is most commonly a selection of finely ground metallic oxides mixed and suspended in oils, though many preparations—known as water paints—are now in common use, the mixing liquid being water.

For the preservation and decoration of timber and metal work oil paint is most extensively used.

484. Preparation of oil paint. Oil paint consists essentially of a *base*, a *vehicle* and a *colouring pigment*, unless the natural colour of the base is satisfactory. It is often an advantage to add a *solvent* and a *drier*.

Base. The base is the "covering medium", or "body", of the paint. For this purpose white lead, red lead, zinc white and iron

oxide are the chief materials employed, being prepared by grinding in oil.

Vehicle. A vehicle is the fluid employed to float the base, by holding it in fine distribution and suspension and enabling it to be spread. The vehicle must also provide a tough skin in the process of drying thus connecting and covering the basic particles of the paint. Oils are chiefly used as vehicles and include raw linseed, boiled linseed, poppy, China wood and other vegetable oils.

Colouring pigments. These are colouring matters of mineral, vegetable and animal origin, which are mixed with the base and vehicle to obtain any desired tint. They must not detract from the durability of the paint and should be "fast" colours, not easily affected by sun and weather.

Solvent. A solvent is used to enable the easier mixing of base, vehicle and pigment to be accomplished and to make the paint work freely. Oil of turpentine (commonly known as "turps") and turps substitutes are the usual solvents.

Driers. As most oils dry slowly it is often an advantage to hasten the process by adding some suitable material. Oils thicken and dry by oxidation and most driers convey the power of quick oxidation. Turps acts in this way and also litharge, terebene and "patent driers". The latter detract from the durability of the paint if used in excess.

485. Preparation of wood surfaces for painting. Surfaces of woodwork to be painted should be dry, clean, well wrought with sharp tools and finished with fine glass-paper to remove possible tool marks. They should also be free from risen grain, dents and bruises.

Nails should be punched sufficiently below the surface to allow of permanent putty stopping.

The painter's operations may then be taken in the following order.

486. Knotting. Large knots should not be allowed in good work. If knots exist the first process is to "kill" them, viz. coat them with a substance which will prevent resinous matter exuding and discolouring the paint when subjected to the sun or to artificial heat. The usual practice is to give two coats of "shellac knotting", lightly glass-papering the first coat when hard before applying the second coat.

In high class work knots are covered with metallic leaf such as tin foil, or aluminium. Gold leaf is also employed.

487. Priming. The first coat of paint is known as the "priming" coat; its function is to stop the pores, penetrate into all crevices and nail holes and thereby provide adhesion for the stopping of the

latter. Loose woodwork, such as doors, sashes and opening lights, should be thinly primed on completion of the framing, then, after fitting and hanging, re-primed immediately to cover all newly wrought edges and surfaces.

Priming paint for timber may be composed of five parts of white lead and two parts of red lead, thinned to a working consistency with raw linseed oil.

488. Stopping. When the priming is dry, all nail holes, defects and crevices are filled or "stopped" with putty or hard stopping. Putty is slow in hardening unless mixed with a small quantity of turps, or terebene, or other drier.

489. First and succeeding coats. The various coats of paint applied *after* the priming coat are named in the order of their application, as first, second, third, etc., except that the last coat is called the "finishing" coat.

In coloured work it is well to insist on a different tint for each coat in order to allow the number of coats to be easily checked by the supervisor during the progress of the work.

In this description we shall assume that white paint is to be employed throughout.

490. First coat. This coat may consist of white lead, raw linseed oil and 5 to 8 per cent. of patent driers, thinly applied on a glass-papered surface over the priming.

491. Second and subsequent coats. May be of similar material and proportions with a variation of the vehicle to suit the nature of the work, *e.g.* exterior or interior.

For *exterior* work, white lead, pale boiled linseed oil and a very little turps, give satisfactory results.

For *interior* work, five parts of white lead to four parts of zinc white may be mixed with almost equal quantities of raw linseed oil and turps, the former being a little in excess. Patent enamelled finishing coats may be satisfactorily applied over this composition.

492. Time for drying between coats. It is important that the time allowed for drying should be ample. An additional coat should not be laid until the previous one is dry and hard, otherwise the shrinkage of the earlier coats will cause the later ones to crack.

Twenty-four hours is the *least* period which should intervene but the personal inspection of an expert should be relied upon for deciding when to proceed.

Each coat should be rubbed down with fine glass-paper and dusted as a preparation for the succeeding coat.

493. External varnish finish. External work may be well finished and preserved by adding one or more coats of transparent "oil varnish" upon the thoroughly hardened paint. Thin applications are necessary to successful work.

In some cases the coat of paint immediately preceding the varnish is prepared with very little oil, its place being taken by a small quantity of the finishing material mixed thoroughly with the paint in order to bind the base. When this is dry the surface is smoothed by rubbing down with fine pumice powder and soft felt, then dusted off and varnished.

494. Internal varnish finish. Varnishes for internal work are prepared with a different object in view. Oil varnish is suitable for exterior work because of its elastic qualities, but it is not suitable for frequent handling. Hence internal varnishes are prepared to withstand handling and are of the harder and quicker drying kinds such as "inside church oak", and "hard copal" varnishes.

Varnishes may be obtained suitable for almost every specific purpose arising in regular decorative practice.

495. Flatting coats. Oil paint, as above described, dries with a fairly glossy surface, and varnish finishes with a high glaze. Flatting paint is prepared to avoid this effect, which is due to oil and resinous gums in the paint and varnish respectively; turps only are used as the solvent and vehicle, and the result is a dull or dead surface, sometimes called a "matt" finish.

The flatting coat is an exception to the rest and is best applied upon the preceding coat of oil paint before it is thoroughly dry.

Flatting finishes give a soft effect if well carried out on specially good woodwork and have the further advantage that they do not show up surface irregularities in work which is not so satisfactorily finished. They will not generally bear washing and cleansing, however, without serious deterioration, and are only suitable for high class work which can be frequently renewed.

Finger plates of adequate size and number are very necessary on doors which are finished without gloss.

496. Enamel finishing coat. For highly glazed work enamels are in demand. They are very durable and are prepared by combining good quality paint and varnish in the manufacturing process and produce a much whiter surface than can be obtained by separately painting and varnishing. Special enamels are prepared for obtaining a comparatively dead or matt finish while giving a hard face much superior to ordinary flatting paint both in appearance and durability.

Bath enamels of a more elastic character are also prepared for renewals. These allow of considerable expansion and contraction

due to quick changes of temperature. The best work is obtained by laying them on a groundwork of quick and hard drying paint. The original enamels are so prepared as to need "stoving", which gives them great durability.

497. Oil finish. External oak work is often preserved by coating with oil in order to present the natural appearance of the grain, though the material will resist the weather remarkably well without any such preservation and assumes a pleasant silvery appearance in the process of weathering in a clean atmosphere.

Where oil preservation is desired the surfaces are cleaned with turps and then coated with pale boiled linseed oil. A number of coats may be thinly applied at intervals of several days, and it is an easy matter to renew these as required.

High gloss paints are also in frequent use for internal and external work where a hard wearing, easily cleansed surface is desired. While not equal to enamel, they give a very satisfactory finish, but the modern synthetic paints usually employed for this purpose have not yet proved as durable as some of the older forms of paint with a lead base.

498. Oil stain. Deal timber in external work is often treated with an oil stain of selected tint; the grain of the material is visible and adds to the effect if the stain is used skilfully.

Varnishes may be applied over oil stains when quite dry.

The tints generally selected are warm greens and browns, and by judicious mixing many acceptable shades may be obtained.

499. Water stains. Water stains are also in common use for application to soft wood timbers. Coloured pigments which easily mix with water are employed.

An advantage of water stain is that it penetrates the wood more effectively than oil stain, but this is somewhat offset by the liability to raise the grain. To avoid the latter as much as possible the material must be very dry and the wrought surface finished with sharp tools. Excessive and heavy glass-papering is detrimental to the work as it presses down the softer portions of the fibre which rise on the application of the stain.

Before varnishing, a coat of size[1] should be applied over the stain and allowed to dry thoroughly. Size may only be omitted if several coats of varnish are specified.

500. Spirit stains. These are prepared by mixing the pigment with methylated spirits (spirits of wine); the stain penetrates well and dries quickly, with a better binding effect than water. It is

[1] See Chapter on Materials, paragraph 727.

wise, however, to apply a coat of size over spirit staining, unless three coats of varnish are to be used.

501. Graining. Graining is the term applied to the artificial representation of woods, the object being to reproduce the grain as well as the colour. The last coat of paint is selected of a suitable tint to form a groundwork, upon which a graining coat is laid either in oil or water colour; the tint of the latter resembles the darker part of the grain of the timber to be represented.

By means of special combs, brushes and rags the graining artist removes portions of the surface coat before it is dry and, according to his knowledge of the timber to be represented and his operative skill, produces a more or less satisfactory imitation.

The best work is also *overgrained*, namely, coated over the graining with thin colour almost transparent, to obtain a greater variation of light and shade. All grained work must be varnished as described for previous finishing coats.

Oak graining is most popular and is best done in oil colour while other woods such as walnut, mahogany, teak and ash are usually grained in water colour.

Much of the cheap graining does not truly represent any kind of hardwood timber and is very objectionable; it is a debatable point as to whether any timber is so ugly that it must be made to imitate another.

502. Successive coats of varnish. Where coats of varnish are to succeed each other for any of the purposes described above, the previous coat must be quite hard and should be flattened down by rubbing with fine powdered pumice stone and felt; the pumice powder must be completely removed by washing down before proceeding with the over-coat.

503. Painting on old woodwork. Woodwork which has been previously painted needs to be treated in accordance with the condition of the paint.

If in fair condition, free from cracks, blisters and wrinkles it may be smoothed down with glass-paper or with fine lump pumice stone and water.

Small defects may be remedied by stopping as described for new work.

If the surface of the paint is seriously defective or the coats have not hardened properly, the whole of the paint should be removed. This may be accomplished by the use of an approved paint solvent or softening by a spirit lamp and scraping off. The former method is preferable if a satisfactory solvent is obtained.

After removal of the paint the procedure compares exactly with that for new work.

If rubbed down, at least two coats of paint will be required and an additional coat if the colour is to be changed from a dark to a light tint.

Painting on Ironwork

504. The preservation of ironwork is of great importance. When subjected to the action of moist air, iron rapidly oxidises, producing the brown coating known as rust.

The object of painting is to prevent oxidation by keeping moist air from having contact with the metal.

In new work where the surface is free from scale there is little difficulty in ensuring good work provided that reasonable care is taken, but in old work, where neglect to renew the paint has resulted in the oxidation travelling underneath the surface from exposed or improperly executed work, it is a difficult matter to ensure efficiency of the new covering.

In any case all scale and flakes of rust must be removed and the surfaces brushed clean, so that the paint comes into direct contact with the metal; the work should also be done in dry weather to avoid deposit of condensed atmospheric moisture on the metal or between the coats of paint.

505. Paints suitable for ironwork. For priming ironwork the base should be of very finely ground material.

Iron oxide is in common use for the cheaper work and is quite satisfactory if mixed with good materials, but the best protection is considered to be afforded by a priming coat of red lead and boiled linseed oil followed by a similar coat after fixing.

The first coat should be applied to cast iron as soon as it is cool enough to manipulate after removal from the sand moulds. The metal must be brushed clear of sand and trimmed where necessary, then primed immediately to obtain the best results.

Rolled metal, as in bars, joists, angles, etc., is not in a condition for immediate treatment, because a surface scale forms during the rolling process which is difficult to remove at once. Exposure to the atmosphere facilitates this removal by causing oxidation to commence beneath the scale, which is loosened by the expansive force of the metal in the process of change.

It is important that mill scale should be removed before the metal is painted and there is no objection to a fine coating of rust if the priming coat be well worked to absorb it. The slight roughness of the surface improves the adhesion of the paint.

The coats of paint succeeding the priming need to be elastic to accommodate the expansion and contraction of the metal, especially in external work exposed to the sun.

Ordinary well prepared oil paint with white lead or zinc oxide

(or both) as a base, and boiled oil as a vehicle, gives good results, but of recent years several iron preservative solutions have been used, most of which have a bituminous base. They give highly satisfactory results from a preservative standpoint but in many cases the aesthetic value is low.

They are more suited to engineering structures such as bridges, dock fittings, etc.

506. Painting on galvanised metals. Galvanising is the process of depositing a coating of zinc by electrolytic methods. Usually, painting on such surfaces is not required, but if deterioration occurs, or it is decided to paint the surface to correspond with surrounding objects, then special treatment is necessary to ensure satisfaction.

All grease must be removed by a dilute acid wash and the priming coat may be prepared from zinc oxide and linseed oil, or as an alternative, a reliable water paint. The succeeding coats may be of any elastic paint.

507. Painting on plastered surfaces. All defects in the surface should be stopped with Keene's cement or plaster of Paris about twelve hours before painting commences. As soon as the stopping is set it may be rubbed down and the whole surface smoothed. A coat of glue size is then advisable to prevent undue absorption of the paint.

The primary coat should be applied when the size is quite dry; a suitable priming is made from white lead, raw linseed oil, turps and 8 per cent. of driers. The turps and oil are in the ratio of 1 to 2 and the mixture should be thin enough to work freely. Subsequent coats may be similar to those for woodwork, white lead, zinc oxide, oil, driers and colouring pigments being employed.

508. Painting upon portland cement rendering or upon concrete. Mass concrete and walls rendered with portland cement mortar and coated with ordinary oil paint will not give a satisfactory and durable finish unless some surface treatment has first been applied to counteract the effect of the lime compounds upon the oil.

Being alkaline these compounds may be neutralised on the surface by the application of dilute acid. If sulphuric acid (H_2SO_4) be diluted to a 1 per cent. solution and the face properly washed over, any particles of free calcium oxide (CaO) are converted into calcium sulphate ($CaSO_4$) and the water evaporated. The calcium sulphate is only very sparingly soluble in water and does not affect paint; the surface should be washed to remove any traces of the acid, and thoroughly dried before applying the paint.

Flatting or matt finish is desirable for all comparatively rough surfaces which are painted in this way. The under-coats should be of white lead and oil and the last coat of good quality flatting paint

with a little oil varnish to improve the binding of the particles; as an alternative a flat enamel might be employed for the finishing coat.

509. Painting upon patent plasters. Patent plasters, as a rule, present a fine surface for decorative treatment, but in some cases the paint does not lay freely upon the face owing to the introduction of special materials which constitute the difference between the patent plaster and ordinary plaster of Paris. In most cases a priming of flatting paint, bound with a little varnish, thinly applied, and followed by a first coat of similar composition will serve the purpose and can then be followed by ordinary oil or enamel paints at reasonable intervals.

Many decorators advise that plaster walls and ceilings should not be painted when new, but treated with patent washable distemper as a preliminary decoration in thinly applied coats which will not spoil the surface for an ultimate finish in oil paint.

Distempering of Walls and Ceilings

In the modern decoration of dwellings, domestic buildings and public premises the use of distemper is increasing and much thought and care has been expended in recent years in the production of distempers and water paints which are durable, washable and decorative in a range of desirable tints.

Some of these distempers are mixed with special liquids which have a greater binding effect than water and ensure durability and resistance, while allowing reasonable surface cleansing to be done.

510. Ordinary distemper. This is usually composed of whiting as a base, size as a binder, and colouring pigments where desired, which will readily mix with water. The covering power is good but the coating not so hygienic as some of the patent distempers which claim to be free from size in their manufacture. The size is the only binding medium, no chemical action taking place to harden the material; when dry the distemper may be removed by washing with water.

To prevent absorption and cloudiness plaster surfaces are often coated with a preparation of size called "clearcole".

511. Patent distempers and water paints. Many of these are very satisfactory. They are prepared on a chemical basis and even those mixed with water undergo a hardening or setting process which continues for some time and renders them fairly permanent. With ordinary plaster it is often an advantage to render the surface non-absorptive by clearcoling.

The only serious disadvantage to the use of these distemper decorations is the liability of the plaster to damage by accidental knocks, causing pieces of white plaster to be exposed. From a hygienic standpoint they are preferable to wallpapers.

Lime-Whiting

512. Surfaces of walls and ceilings in such places as outhouses, washhouses, fuel and tool stores, external W.C.'s, workshops and factories are often treated with lime-whiting because of its sanitary value as a deodorant.

Lime-whiting, also called limewash and whitewash, is prepared from freshly slaked pure lime (chalk lime), water and size. It is rougher than white distemper but much more satisfactory for the above-mentioned purposes as it imparts a freshness to the atmosphere and is more hygienic.

It requires frequent renewal and this is demanded by law under the Workshop and Factory Acts.

Polishing

Polishing is distinguished from painting and varnishing by the nature of the process, the former being chiefly applied by rubbing while the latter are invariably laid with a brush.

513. **French polishing.** Where a highly finished, smooth surface is to be preserved which is subject to frequent handling, or unsuitable for painting as in the case of ornamental hardwoods, a satisfactory result can be obtained by French polishing.

The polish is a transparent preparation of selected shellac dissolved in methylated spirits and is applied as follows upon smooth well-wrought surfaces:

The pores are first stopped by a paste filler which is rubbed over the surface with a cloth; when hard the surface is smoothed with very fine glass-paper and the polish applied by saturating a wad of cotton wool, enclosing it in a piece of linen cloth and rubbing over the surface, which becomes thinly coated by the polish oozing through the linen. The latter is free from loose fibre and ensures a free, unstreaked finish. The linen face is occasionally damped with spirits to prevent adhesion. In the very best work the "filling" is done by the polish which is absorbed into and fills the pores, but takes considerably longer to accomplish. Cheap paste fillers often produce defective surfaces after the work is finished.

All woodwork intended to be polished should be prepared in such a way that the parts may be dissembled to be "bodied in", *i.e.* the groundwork or body of polish applied, so that the internal angles of moulded panels, etc., may be cleanly finished to the edges. If

panelled or moulded work be polished *in situ*, muddy angles are unavoidable and salient angles lose their sharpness.

Handrails, newel posts, bath tops, W.C. seats, mantelpieces, vestibule doors, desks, counters, etc., are usually constructed in ornamental hardwoods and French polished.

Colouring is often employed in French polish to change or to modify the appearance.

514. Wax polishing. This finish is obtained by coating the surface of the wood with a stiff paste of beeswax dissolved in turpentine. It is particularly suited to oak fittings and furniture especially where the wood has been fumed with ammonia to give the dark tint of mature age. In the best work a filling coat of spirit varnish or French polish is first brushed on to stop the pores before applying the wax.

The polish is applied with a linen rag and briskly rubbed to fill the pores and coat the face without leaving any excess on the surface.

A dull, pleasant appearance is given to the material comparing somewhat with the matt finish of the painter. It is much superior in this respect to the high gloss commonly aimed at in French polishing; it is highly sanitary, easily renewed and very suitable for oak and other hardwood floors in public institutions.

When newly applied it marks on handling, but gradually improves in this respect; the marks are obliterated by light rubbing.

Paperhanging

515. The use of wallpapers dates from about the end of the 17th century and these were doubtless imitations of the tapestry and silken wall hangings of previous times.

The covering of internal walls by specially prepared paper is probably the most common method of decorating the walls of domestic buildings; they are also largely used for ceilings. So long as the plastering in ordinary dwellings continues to be faulty in lines, planeness and finish, the use of wallpapers will probably continue, because they make these defects less observable if reasonable designs are selected. From a hygienic standpoint the papering of walls is not ideal and where used they should not be renewed by laying one covering upon another, because imperfections, wrinkles, air blisters, etc., tend to harbour disease germs. Because of their highly decorative value, however, wallpapers have become more popular in recent years and will continue to be used.

Special attention has been given to the art of decoration and modern designs are available in excellent outline, and choice treatment and colour.

Re-papering should be done on walls cleanly stripped, rubbed and washed down and re-sized before commencing the papering process.

516. Papering on new walls. The surfaces are presumed to be dry and well finished; if not, stopping and rubbing down may be required, if a first class result is to be obtained.

The surfaces are first sized, covered with white (or tinted) lining paper to form a groundwork and the face of the lining paper sized when dry. This paper must be hung vertically with the edges butted, not overlapped; adhesion is obtained by the use of flour paste, cool but freshly made.

Finishing paper is selected and hung in a similar manner to the lining paper, preferably with the edges butting to avoid ridges. Where the paper is not coloured through, butt jointing is compulsory, but in thin self-coloured papers one edge is commonly cut straight and the other left with a margin to be overlapped by the adjacent piece of paper. Overlapping edges, if permitted, should not be presented to the light where avoidable.

Papering should not be attempted on damp walls.

CHAPTER TWENTY-TWO

MATERIALS

517. In dealing with materials, it is the authors' intention to supply sufficient information for the purpose of recognising, selecting and intelligently utilising those building materials which are in general use, and to afford a guide to the student in the preparation of compounds where such preparation is a part of the builder's work.

Exact knowledge as to the physical and chemical properties of artificial mixtures and compounds is related more to specialised branches of manufacture, but it should be the aim of every student to obtain a reasonable amount of knowledge by the actual examination and testing of building materials, on a scientific basis, in a laboratory.

It should also be recognised that much more valuable information can be gained by handling and comparing pieces of material than by reading descriptive matter alone, and it is desirable for all who are engaged in the art of building to obtain full information relating to local materials and their possible use, and later to study such materials as may be economically transported, or solely obtained, from other districts.

The study should cover not merely the nature and properties of the material but also the aesthetic value when associated with other structural and decorative materials; much useful study can be done in comparing completed structures and noting the qualities and defects due to the selection and disposition of the building materials employed.

Materials used by the Bricklayer

Bricks

518. Bricks are artificial blocks made by baking prepared clays and shales, commonly called brick earths.

Clay is a plastic material composed chiefly of silica and alumina, but with small quantities of other compounds such as iron, lime, magnesia, sodium and potassium. The amount of alumina and the quantity of water present determine the plasticity.

Shale is a partially formed clay rock in laminated beds; it is similar to clay but contains little moisture. Shale is much used for brick making; it is ground to powder and rendered more or less plastic by moistening before being moulded and pressed to shape.

Hand-made bricks are made from plastic clays. These are dug, left to weather for some months during the winter, then mixed, kneaded and moulded to the required shape. Ordinary hand-made bricks have a frog on one side only. They are dried and baked until hard enough for use.

Machine-made bricks may be made either from plastic clay or shale. Generally, plastic clay is forced through an aperture having the dimensions of the bed of the brick, and the thickness is determined by cutting the block of clay, as it issues, with suitably spaced wires. Some shales are ground to powder, or to a rough sandy mixture, reduced with water to a plastic condition and prepared in the same way.

The most usual method of preparing shale, and known as the semi-dry process, is to grind it to powder in a clay mill, moisten, fill into presses and mould and press at the same time. The raw bricks contain little moisture and are soon dried and burnt. Pressed bricks have a frog in each bed, and can therefore be distinguished from wire-cut bricks, which have plain beds. The former are denser and less absorptive, due to the pressure employed in moulding, but the mortar does not adhere so well.

Wire-cut bricks take longer to dry before they can be heated to the burning temperature, and are liable to warp if the drying is hurried.

519. Qualities of bricks. Whatever mode of manufacture is employed, as required by the nature of the available brick earth, the resulting bricks will vary in quality and character and the important characteristics to be noted by the architect and builder are colour, texture, form, soundness, porosity and weight.

520. Colour depends upon the composition of the earth and the degree of heat employed in burning.

Oxide of iron is chiefly responsible for differences in colour, 4 to 5 per cent. producing red bricks and 7 to 10 per cent. blue bricks at sufficiently high temperatures. Buff bricks have less iron and more lime and are often burnt at low temperatures.

521. Texture. The nature of the surface of a brick has much bearing upon its effect in the structure. Smooth, glazed surfaces are never so effective as the rougher surfaces obtained in sand bricks, rough wire cuts, rubbers, etc.

Texture is much assisted by variation in colour, and the latter need not be a cause for rejection of material on the assumption that variation of colour means serious non-uniformity of quality. Multi-coloured, sand faced, rustic and other bricks are now in general use with a view to obtaining surface relief and variety and there appears

to be no reason why the present smooth pressed facing bricks, so common in the north of England, should not be prepared with a rough faced die and so avoid the hard, unrelieved and often objectionable surface; at the same time we must recognise the value and need of such bricks for sanitary engineering purposes.

Texture bricks are not suitable for use in smoky manufacturing towns if too rough, as soot and dirt adhere and accumulate quickly.

522. Form. The form of a brick must be reasonably good and rectangular and there should not be so much variation in size as to interfere with the bond. On the other hand, face work in texture bricks need not be perfectly regular and is indeed improved in appearance by a slight irregularity of form and the use of thick joints.

Speaking generally a good brick should have reasonably true beds and faces, sharp arrises, uniform dimensions, correct relation of length to breadth and the faces and beds approximately at right angles to each other.

523. Soundness. This refers to the physical condition of the brick, whether free from cracks, flaws, lumps and defects causing easy fracture or vulnerability to driving rain. It also refers to the nature of the burnt material, whether loose and earthy or fused and vitrified into a cohesive mass.

Fusion can only be partial or the brick would not retain its shape; it is assisted by the presence of lime, sodium and potassium compounds in small quantities, which act as fluxes and cause some vitrification at low temperatures.

Soundness may be tested (*a*) by striking two bricks together; they should give a clear ringing sound; (*b*) by an examination of a fracture, which should be fairly homogeneous.

524. Porosity is due to a lack of density. The particles of cohering matter are partially divided by minute spaces or voids, which allow water to be absorbed if the voids are sufficiently connected and continuous. Earthy, unvitrified bricks are also very absorptive and these are the most unreliable and dangerous because they will deteriorate rapidly in damp situations.

Porosity in sound bricks is not necessarily a defect; it often results from the attempt to produce an artistic brick, because texture bricks are more open in the grain and the surface not vitrified.

Used in hollow walls or in thick solid walls, these bricks are quite satisfactory; when used with ordinary lime mortar in thin walls they compare very favourably with dense bricks for maintaining dryness of the interior, because the line of weakness in the latter

case is the porous mortar joint which absorbs water quickly and directly through the wall, while in the former case relief occurs by some of the water being absorbed vertically into the bricks.

Further, porous bricks dry out as readily as they absorb.

525. Weight. This quality is only of importance for engineering work. Weight infers strength and resistance to movement and is valuable in heavy structures.

Ordinary brickwork has a density varying from 100 to 140 lbs. per cu. ft., while single bricks vary in weight from 6 to 10 lbs. each, according to the kind of material and the size of the brick.

An average weight for purposes of calculation is 1 cwt. per cu. ft.

526. Selection of bricks. In selecting bricks for any special purpose, the type and quality is required which best suits all the conditions to be met.

Bricks for foundations should be sound and hard burnt, those for interior use are usually of some common local quality, or, if not made locally, of some brick which is not too costly in carriage to prohibit its general use.

For facing work of an ordinary character, bricks are often selected from deliveries of common qualities, but there are usually good local "stocks" available for this purpose in addition to the many special facings of texture bricks referred to in previous paragraphs.

527. Durability of bricks. Good bricks are very durable under normal conditions in addition to being highly fire-resisting. If sound, of good form and well built in good mortar, brickwork is also durable, but attention must be paid to the joints and any deterioration made good by raking out and pointing the joints. Otherwise, water which collects on the edges of the bricks at deteriorated joints will be absorbed by the materials and will cause chipped and fractured edges, especially in frosty weather.

528. Varieties of bricks. It is impossible in any text-book to give an adequate description of the many varieties of well-known bricks. Some areas, however, produce large quantities of bricks more or less similar in character and colour, because of the existence of extensive deposits of similar brick earths. This occurs around London, in the Midlands, North Wales, East Lancashire and many other parts of the country and as a matter of general knowledge the characteristics of these bricks should be known and appreciated.

529. London stocks. These are largely hand-made from the London clay. Their colour is a yellowish brown or buff, the surfaces somewhat rough and irregular, arrises faulty, but moderately hard and fairly durable in the London atmosphere. The appearance is

good and they are used for the mass of middle class work; occasionally "picked stocks" are employed as facings in good work.

530. Fletton bricks. Made by machinery, from shale, which is utilised in the semi-dry process referred to in paragraph 518 and burnt in continuous kilns.

It is one of the cheapest bricks on the market, has a pleasant variable reddish buff colour, with faces more regular and smoother than London stocks; the face is hard, but the interior is softer. These bricks are manufactured near Peterborough—Northamptonshire.

531. T.L.B. rubbers and facings. These bricks are produced in Berkshire in the neighbourhood of Bracknell and Ascot and are known and used all over the country.

The rubber bricks are specially prepared for good work where unusual forms are required; they cut and rub to shape with great facility and yet are durable except in damp and acid atmospheres, or where subject to abrasion.

Three pleasing tints are obtainable, viz. orange, cherry and dark red.

Facing bricks are somewhat similar to the rubbers, but are burnt harder and are less in size; the rubbers are made specially large to allow for conversion to gauged blocks.

The texture and colour of hand-made T.L.B. bricks may be varied through a sufficient range to suit most purposes and many tastes; these bricks are very absorptive when first exposed to the weather. Dark, hard burnt, machine-pressed bricks are also made for damp-resisting purposes, foundations and similar work.

532. Blue bricks. Very heavy, hard bricks made from tenacious clays containing large quantities of oxide of iron. They are burnt at high temperatures, which convert the oxide into "black oxide" and produces a dark "slaty blue" brick, well fused, of great density and exceptional strength.

If a quantity of oxide of manganese is present with the iron a black brick will result.

Blue bricks are made in several parts of this country, but the best known are from Staffordshire, Worcestershire and North Wales. They are employed for damp foundations, damp-resisting courses, piers supporting heavy loads, exposed angles of buildings, large span arches, street manholes, etc.

533. Lancashire facing bricks. Excellent facing bricks are produced in Lancashire and similar bricks in some parts of Yorkshire. They are made by the semi-dry process, prepared, moulded and pressed entirely by machinery, and are dense, impervious and of

uniform bright red colour. The size is usually $9'' \times 4\frac{3}{8}'' \times 3''$ and the work rises four courses to 13″. The best qualities are very true in form, with frogs on both sides, and are in great demand for sanitary engineering purposes.

534. Welsh bricks. Some of the best clays for the manufacture of bricks, terra-cotta and tiles, are found in North Wales.

Fine quality pressed bricks are obtainable in red and buff colours, and also glazed and enamelled.

Bricks from the Ruabon district are very reliable in quality and have been widely employed for good work in England and Wales.

535. Leeds bricks. Common bricks and facings are made in large quantities in the Leeds district and some neighbouring parts of West Yorkshire. Glazed firebrick facings, glazed and enamelled partition bricks and fine terra-cotta blocks are also produced. All these latter, together with facing bricks and sanitary ware, are of a high quality.

536. Firebricks. These bricks are made from special clays known as fireclays, which contain a great proportion of silica, and are fairly free from fluxes; they will resist high temperatures.

Firebricks are used for the sides and backs of fire grates and for setting domestic hot water boilers. Most of them are of a light buff or pinkish buff colour, and rough and gritty to handle; in many cases they are easily broken, thus requiring careful handling and setting.

Firebricks should be set in ground fireclay made into a paste, or in portland cement mortar.

Amongst the best known firebricks are: Stourbridge (Worcester), Ruabon (N. Wales), Leeds (Yorks.), Halifax (Yorks.), Poole (Dorset), Dowlais (S. Wales), Newcastle-on-Tyne (Northumberland), Glengarnock (Scotland).

537. Special texture bricks. Realising the importance of texture and colour in surface work, special efforts have been made in recent years to produce bricks the surfaces of which possess artistic qualities. Some of these have been very successful, either by reason of the surface alone, or the harmonious blending of colour tones, or both, and have been in great demand for modern housing developments in suburban rural areas.

Notable examples of vari-coloured bricks and texture are to be found in Berkshire, Lancashire, Leicestershire, Lincolnshire, Kent, Staffordshire, Sussex, Surrey, Yorkshire and North Wales.

538. Sand-lime bricks. Bricks manufactured by the "silica-lime" process have been successfully employed on the continent for many

years, and, due to exigencies of war, have been recently manufactured in considerable quantities in England.

Under certain conditions when silica and lime are brought into intimate contact they are able to combine and form silicate of lime. Many natural materials and trade wastes contain the necessary amount of silica for the manufacture of bricks, *e.g.* sand, slate waste, granite waste, boiler ashes, refuse destructor clinker, burnt shale (colliery heaps) and blast furnace slag.

The basic material to be employed is, if necessary, broken to pass $\frac{1}{8}''$ to $\frac{3}{16}''$ sq. mesh, then intimately mixed with 9 to 18 per cent. of hydrated lime. (This is equivalent to 6 to 12 per cent. of fresh lime.)

Good quality lime, rich in calcium, is required, such as Buxton and chalk lime; thorough hydration must be ensured to avoid the expansive action of unslaked particles during the maturing period.

The two materials are automatically measured in a pre-determined ratio and delivered to the brick press. This latter must be capable of exerting a high pressure to ensure consolidation, on which depend the density and strength of the finished product.

The pressure required is up to $2\frac{1}{2}$ tons per sq. inch, but varies with the materials.

Raw bricks are transferred from the press to hardening chambers where they are subjected to the action of saturated steam at a pressure of 165 lbs. (or less) per sq. inch for periods from 6 hours upwards, or at atmospheric pressure for periods up to 24 hours, the pressure and time depending upon the nature of the bricks.

"Lime-sand", "lime and slate waste", and "lime-granite" require high pressures and can be successfully hardened in 6 hours if steamed at a pressure of 165 lbs. per sq. inch, or in 10 hours if the pressure be 120 lbs. per sq. inch. Other materials can be hardened by steam at atmospheric pressure, but require longer periods; as an alternative they may be steamed at low pressure for 6 hours and matured by stacking for three weeks in the open air.

Hardening can be done entirely in the open air by stacking directly from the press, under cover. This is the cheapest method but takes approximately three months to harden bricks sufficiently for use.

539. Uses of sand-lime and similar bricks. Most bricks of this class possess little architectural value, as compared with all except the commonest clay bricks. Yet with careful selection of the materials and some practicable treatment for the improvement of the surface texture, a reasonable use should be found for their employment in face work.

For backing, general internal building and for structural work of reasonable dimensions, no objection can be taken to their use if periodically tested on the introduction of new basic materials.

540. Concrete bricks are now being produced by such machines as the Vickers' patent, in which nine bricks are moulded at once on separate iron pallets and discharged at one movement of the controlling lever.

The bricks are $9'' \times 4\frac{1}{2}''$ and any thickness up to $4''$. Any fairly fine aggregate may be employed, with sand and portland cement, or with cement alone, in the proportion of 1 to 7; the materials are moistened, filled and rammed by hand, and are firm enough to remove for hardening, which takes at least four days.

To obtain reliable bricks the mixture should not be moulded too dry, and as long a time as possible should be given for maturing.

541. Paving bricks. Specially made bricks are available for use as paviors, Dutch and adamantine clinkers being the best known. Any hard, well vitrified brick is suitable if it does not become too slippery, a fault common to blue bricks. If intended to be used as paviors the edges should be chamfered or the surfaces serrated or embossed as in the case of some paving tiles.

Dutch clinkers are $6'' \times 3'' \times 1''$ or thicker, burnt at a very high temperature, and are very durable but often warped and irregular.

Adamantine clinkers are the hardest, densest and best wearing paviors on the market. They have a pinkish tinge and pleasant appearance and are manufactured in various forms suitable for kerbs and channels to stables, and for public footpaths.

542. Glazed bricks. Bricks of good form and quality are often glazed in order to fit them for special sanitary purposes or for positions where non-absorbent bricks are necessary.

The commonest method is known as *salt glazing*. In this process sodium chloride (common salt) is thrown into the kiln during the burning process. The heat volatilises and decomposes the salt, liberating chlorine gas, which passes off through the flues, while the sodium in the vapour comes in contact with the exposed faces of the bricks where it combines with silica in the brick earth and forms sodium silicate (or glass).

The same method is adopted for glazing earthenware and stoneware in sanitary pipes and fittings of ordinary quality, and for bonding bricks for cavity walls.

543. Enamelled bricks. These are bricks which have been coated on one or more faces with a preparation called enamel, which when placed in the kiln vitrifies, attaches itself firmly to and partially combines with the elements of the brick and produces a white, or coloured and highly glazed surface, according to the base and colouring pigments employed. In some cases the colour is due to chemical changes which take place on heating.

The enamels are sometimes applied to bricks which have been

previously burnt, but the more modern method is to paint the enamel on the raw brick and thus avoid a second placing in the kiln.

Plain glazed tiles are largely prepared in a similar manner.

Limes and Cements—Mortar

544. Mortar is employed for bedding and jointing the units of brick (or stone) in order to distribute loads more uniformly than would be possible by bedding one block directly upon another, and also to unite the blocks to make the joints between them weather resisting.

Every mortar consists of a cementing material such as lime or cement, which may be diluted—and often improved—by the addition of an inert material, *e.g.* sand, ground clinker, etc.

The mortar must be a cohesive mass which will not only set hard, but adhere to the bricks or stones and so unite them.

545. Limes are "products of limestone" obtained by heating the stone to redness in air, leaving a substance commonly known as "quicklime", and to chemists as "oxide of calcium". When water is added to quicklime it "slakes", the mass breaking down from the lump to a moist powder and the action taking place rapidly or slowly, according to the ratio of pure calcium oxide contained in the bulk.

546. Cements are natural or artificial lime compounds in which—after burning as described above, but at higher temperatures—no visible slaking action occurs. Addition of water would not successfully break the mass to powder, nor reduce it to a state of plasticity, hence "grinding" becomes necessary.

A further distinction may be made, viz. that limes depend more or less on *air* for their setting properties, which causes some considerable time to elapse before they harden throughout, while cements are quite independent of air and will set in damp situations promptly and permanently.

It should be noted that limes may, and do, gradually approach cements in character, due to their original composition. If the limestones contain clay in quantities varying from 6 to 25 per cent. of their bulk, when burnt they become hydraulic limes and are more independent of air for setting, as the quantity of clay increases.

547. Lime mortar is a mixture of one part of slaked lime and two to three parts of clean, sharp sand, and sufficient water to render it "plastic" without becoming "fluid".

The lime used may be:

(*a*) Blue lias lime.
(*b*) Grey chalk or stone lime.
(*c*) Pure or white chalk lime.

548. Blue lias lime possesses properties which, in a fair degree, approach those of a cement, and is therefore known as a moderately hydraulic lime, setting in damp situations and quite suitable for foundation walling, footings, and exposed positions. *One* part of lias lime to *two* or to *two-and-a-half* parts by measure of sand is the common ratio.

Lias lime should be obtained ready ground to a fine powder.

549. Grey chalk lime is used for all ordinary building purposes in the ratio of *one part* of lime to *two-and-a-half* or to *three parts* of sand. It slakes fairly easily, and requires sand in greater quantity to render its mass penetrable by air, to induce setting.

550. Pure lime is not largely used for ordinary mortar, because it possesses no power to set apart from atmospheric or artificial influences.

For ordinary mortar it should have 3 to 3½ parts of sand to 1 of lime, but is not recommended unless external pointing of the joints is done in cement mortar (see paragraph 556). Even then the interior sets very slowly and settlements continue for a long time after the joints are made, as the load upon them increases.

Pure lime when slaked and mixed with water is very fatty, and resists passage of air, but absorbs moisture easily when set and dried. When prepared by mixing it with a large quantity of water, screening through a hair sieve and evaporating until of the consistency of thick cream, it is suitable either for the plasterer, or for setting gauged brickwork in arches, etc., where very fine joints are desired.

551. Sand is employed in making mortar with one or more of the following objects in view:

(*a*) It makes the use of the purer limes possible by reducing the fattiness of the compound, counteracting shrinkage and conducting air further into the more porous mass of mortar.

(*b*) It provides a means of increasing the "cohesion" if the sand is clean and rough in grain, because the particles of lime adhere to the sand much better than to each other.

(*c*) In the limes and cements not requiring sand to enable them to set, and which in many cases would develop a strength greatly in excess of any necessity, the sand provides a means of economy.

Sand must be free from clay, vegetable earth and greasy impurities and for "building mortar" or "concrete" is preferably rough and gritty, providing irregular surfaces for the lime to adhere to.

Sand obtained from river beds is generally very clean, but not sharp. If fine it is more useful to the plasterer.

Sea sand, though much used for mass concrete in sea front engineering, is unsuitable for architectural building. It is rounded in grain, often too fine in grading and is impregnated with salt which causes efflorescence.

Crushed sandstone is a good and efficient substitute. Many samples of sand which are sharp, but not clean, may be made satisfactory by thoroughly washing to free from clay and vegetable impurities.

552. Sand substitutes. In many industrial districts mortar is made by grinding engine ashes with water in a mortar mill, and incorporating sufficient lime with it when the ashes have been reduced to a paste.

By careful use and efficient supervision very good mortar may be produced. The ashes provide a means of rendering the mixture sufficiently porous to admit the air necessary to setting, and also introduce substances which add to the setting power of the lime compound.

Careful choice of ashes is required in good work, as the sulphur compounds sometimes contained cause discoloration of the wall surfaces at the joints.

The resulting mortar is of a dark grey colour, often nearly black. It sets hard and firm on the exposed edges within four or five days. One part of lime to $2\frac{1}{2}$ parts of ashes is a good ratio.

553. Black mortar is commonly made in engineering districts from sand which has been employed in making moulds for metal castings, and in the process has become black with loose carbon and the graphite which is employed to smooth the moulds and prevent adhesion of the metal.

This again introduces an element—carbon—which assists the setting, though air is still necessary for the process. The ratio of lime to sand is commonly "one to three". Mortar of this type lacks cohesion owing to the greasy nature of the graphite.

554. Setting of limes. Pure limes entirely, and other limes in differing degrees, set by the combination of the moist "calcium oxide" with "carbon dioxide" derived from the air. The combination produces "calcium carbonate", which in composition resembles the original limestone from which the lime was obtained, but without its perfect crystallisation and lacking its original density. It does, however, crystallise and adhere to the sand and the presence of water is necessary for this process.

The slowness of setting is due to the very small percentage of carbon dioxide present in the air, which is about ·04 per cent. under normal circumstances, and also to the difficulty with which air

penetrates the mass of wet mortar; hence, the use of more or less hydraulic limes for jointing stones, or the addition of ashes and foundry sand to pure limes.

Black mortars are often architecturally objectionable, and in such cases ground lias lime or grey chalk lime compounded with clean gritty sand should be employed. If white joints are desired they may be pointed with a mortar composed of grey chalk lime and ground portland stone or white sand.

555. Portland cement. This is an artificial preparation made from lime and clay and its manufacture is now a most important industry. For work of any importance the product is required to reach a standard defined by the British Standards Institution specifications, and particularly when used as a structural material.[1]

Portland cement is the strongest and most reliable building cement in use, and is employed for most external purposes where a cement is required. When used neat, that is without sand, it is practically impervious to moisture.

Further notes on properties of cement are given in Materials used by the Concretor, which is contained in Vol. III.

556. Portland cement mortar. As a mortar this cement is employed by compounding it with sand, the latter varying from one to five parts along with one part of cement, according to the purpose and the degree of imperviousness desired.

It may be employed for bedding and jointing brick cills, cornices and projecting parts, and for external pointing and plastering.

For pointing external joints, neat cement is commonly employed and in no case is it wise to employ more than one part of sand to one of cement. Some cements crack when used neat, owing to faulty manufacture; the sand helps to counteract the shrinkage.

557. Preparation of lime mortar. If the mortar is to be prepared by hand and lump lime is employed, it is heaped on a platform or surface of suitable material and to some known measure. While heaping up, water is sprinkled continuously through a rose until the lime is saturated enough to ensure complete slaking.

The proposed quantity of sand is then measured and piled over the slaking lime, to cover it fully and keep in the moisture and the heat which develops during the action of slaking. The enclosed moisture is conveyed from particle to particle of the lime both by absorption and as vapour, and the quicklime is thus converted into hydrate of lime.

[1] Full particulars of the standard can be obtained from the Secretary to the Institution, 28 Victoria St., Westminster, London, S.W. 1.

Pure limes slake quickly but hydraulic limes in the lump may take several days thoroughly to disintegrate. When the slaking action is complete the sand and lime are turned over and mixed and screened to remove any lumps of dead lime, water is then added, the whole turned over, raked through and mixed to a uniformly plastic condition.

Rich lime mortar so prepared sets very slowly and may remain for a few days without detriment before using. Grey chalk lime mortar should be used within 24 hours of being mixed, while ground blue lias lime mortar must be used on the day of mixing, within a few hours.

558. Hydrated lime. When lime is slaked it absorbs water and increases in bulk without showing signs of moisture, and is thoroughly slaked when it ceases to do so; excess water then makes it plastic.

Lime is now commercially prepared in this hydrated condition and much of the labour of builders' preparation is eliminated.

Hydrated lime only requires the addition of sand, well mixing while dry and then sufficient water added to make the material plastic and workable.

It should not be used in a perfectly fresh condition, but should be prepared a few days before required for use.

559. Preparation of cement mortar. The portland cement employed should be of fresh manufacture when delivered and kept dry until used; damp soon renders it inert and if left in sacks exposed to a damp atmosphere its cementing properties are quickly reduced.

Cement mortar should be prepared on a wooden board, or other clean surface, and must be mixed in small quantities and used at once; setting commences as soon as the cement comes in contact with water. This applies whether the cement is used neat or with sand, and no cement mortar should be broken up and re-mixed after setting has once commenced, because its cohesion is much reduced.

If a cement is hot it may be cooled by air slaking, viz. spreading out on a floor to a depth of 3″ or 4″ for a period. This is seldom necessary with modern methods of manufacture, aeration being accomplished in the final stage of production.

560. Rough tests for portland cement and cement mortar. Portland cement is a scientifically prepared material made from lime and clay, and its successful manufacture requires considerable skill and care. To ensure uniformity of composition, the mixture requires analysis at different stages of the manufacture, and to

obtain the properly burnt and finely ground cement representative of the best modern manufacture, adequate and effective kilns and machinery are necessary.

While scientific testing for assessing the properties of cement and cement mortar are now in general use, and referred to in Vol. iii, it is well to note some of the older tests for quality and condition which are used by workmen and foremen in the absence of scientific apparatus.

For aeration. All cement should be sufficiently aerated, in order to ensure that any particles of free lime may become air slaked, and so avoid unsound work when employed in mortar or concrete; if the bare hand and arm be plunged into a sack of cement there should be no feeling of "heat" nor "cold". If much above blood heat there is probably a quantity of free lime present, while if cold it is indicative of over-exposure and may result in defective setting.

For expansion. Cement which is not properly cooled, or unsound, may seriously expand in setting. An old test is to fill a glass bottle with neat cement paste, quite plastic but not over wet; if sound it should not expand nor contract seriously. Hence, if the bottle remains uncracked, and the cement does not become very loose, the material is probably sound. There is no indication of strength involved in the reference to soundness.

For correct consistency for use as mortar. Good mortar is just plastic enough to leave the trowel cleanly; if the trowel be bright there should be no stain left by the mortar. This condition assumes clean sand to have been employed.

The consistency is sometimes tested by kneading a small ball of mortar in the hand. If too much water has been employed, small beads of moisture will form on the surface.

For setting qualities. Small balls of mortar may be formed and dropped from a height of 20″ to 24″ on to a clean hard surface at intervals. At first they deform considerably, but as the setting process continues the deformation becomes less and when negligible the cement can be considered "set". The time taken to set is observed and noted. The final setting time for a neat cement may vary from 30 minutes to 10 hours.[1]

561. Quantities of materials for mortar. Mortar composed of one part of lime to three parts of sand shrinks roughly one-third of the bulk of the dry materials employed in its manufacture, hence if measured in cubic yards, 4 cu. yds. of dry materials would make $2\frac{2}{3}$ cu. yds. of mortar. It would appear that the mixture should at least produce a volume equal to that of the original sand, but the whole of the lime or cement is absorbed in the voids of the sand and

[1] See Chapter on Materials, Vol. iii.

a further shrinkage occurs due to moistening and consolidating the mixture in working it up.

If 4 cu. yds. of mortar are required, 1½ cu. yds. of lime and 4½ cu. yds. of sand will be employed in making it.

Water employed for mixing mortar should be clean and fresh, and the amount required is approximately one-third of the bulk of the dry materials employed.

Sea water should not be employed. The salt contained in it retards setting, and is liable to produce efflorescence.

562. Use of mortar. All mortar must necessarily remain in a moist condition until the crystallisation into calcium carbonate, calcium silicate, etc., commences, hence, it should not be laid against very dry and absorbent materials which extract the water and thus prevent adhesion and crystallisation. In dry weather most materials require thoroughly wetting and the more absorbent bricks should be dipped in water before being laid.

Joints in brickwork and masonry should be well flushed, every brick being solidly bedded upon the course below and the mortar flushed into the vertical joints by pressing and sliding the units into position.

563. Grout. Grout is a thin preparation of mortar which will flow into position; it is sometimes found to be an advantage to make sure of all interstices between building blocks being filled solid, by employing grout. Rich lime grout is poor and unwisely employed, but cement grout may serve a useful purpose where flushing of joints cannot be accomplished during building, or where a waterproof wall is required. Even in the latter case, it is preferable to render the face with waterproofed cement or to run hot asphalte into vertical joints to ensure resistance to damp.

Grout is sometimes employed to fill the spaces between paving blocks, after levelling them upon fine ashes. The open joints between the bricks—or rough stones—may be first partially filled by sweeping stone chippings into them and grouting up with cement to make the whole surface covering water-resisting.

Brick paving may be properly flushed up as each brick is laid, or the joints made with mortar at the base and grouted up solid from the surface.

564. Damp-resisting courses.[1] Several materials are available for this purpose, including asphalte, bituminous felt, lead, slates, stoneware and blue bricks; also patent compositions such as Hygeian rock.

Asphalte is a limestone impregnated with natural tar and is obtained from France, Switzerland and South America. When

[1] See also Vol. I.

heated and mixed with grit it forms a plastic material which, on cooling, becomes tough, elastic, very durable and damp-resisting. It is laid in the plastic condition and screeded level upon the wall in $\frac{1}{2}''$ layers, run into vertical joints or spread upon dry vertical faces.

Bituminous felt is a fibrous material treated with asphalte which fills the voids and produces a flexible sheet. This is generally surfaced with grit so that when laid on mortar it will thoroughly adhere. This material is an economical substitute for asphalte, but is not so good nor reliable.

Lead. Ordinary sheet lead weighing about 5 lbs. per ft. super. makes a good damp course but the building mortar does not sufficiently adhere to it and it is costly as compared with other materials.

"*Ledkore*" is a combination of lead and asphalted felt. The lead is in a thin sheet or foil and is interleaved between two sheets of felt. It is both efficient and durable, easily laid and economical.

Slates. These may be used in double or triple courses and should be in one width across the thickness of the wall. Such courses must be bedded in rich cement mortar, with half lap bond, and should be left visible at the edges and neatly pointed up.

Stoneware is a form of earthenware in which the earth employed contains few impurities and a large proportion of silica. A high temperature is necessary for fusing and the product is hard, strong and highly satisfactory for resistance to damp and chemical action; the colour is generally buff or yellow. It is provided in either perforated or solid glazed slabs with tongued edges and is set in cement at the vertical joints; when perforated it serves also as a ventilating course, in place of isolated air bricks or cast iron gratings. Continuous courses of these slabs usually provide excessive ventilation under ground floors, causing the rooms to be cold and draughty unless the floor and finishings are of specially good construction.

Blue bricks and slabs. In some districts three courses of blue bricks in cement mortar are employed and form very satisfactory damp courses. Blue slabs are also used in most respects similar in form and purpose to the stoneware slabs described above.

Hygeian rock and other patent asphaltic compounds are employed for damp-resisting work and are particularly suitable for running into vertical walls of tanks and underground chambers in wet soils. The materials have a bituminous foundation, will run freely when hot, set hard and adhere to the units of the wall with great tenacity. They may be used for the same purposes as asphalte.

565. Waterproofed cement.[1] Where mortar or surface coverings must be watertight, the materials may be treated with one of the

[1] See also Waterproofing of Concrete, Chapter on Materials—Vol. III.

pastes or dry preparations provided for this purpose. "Pudlo" is a white powder to be added to the dry cement, mixed thoroughly therewith, after which water is added to obtain plasticity; 2 per cent. of "Pudlo" will give satisfactory results with ordinary cement mortars, not poorer than one of cement to three of sand.

"Novoid," "Ironite" and "Sealocrete" are preparations used in a similar way, all producing good results.

"Prufit" and "Truscon" waterproofing pastes are compounded with the water to be employed for mixing, thus ensuring uniform distribution throughout the mass; they are also dependable.

Bonding Materials

Bricktor and *Exmet* are specially prepared bands of wire mesh for building into brick walls in order to improve the bond in thick walls or to convert a thin wall into a beam by making it capable of resisting tension when tending to sag or buckle.

566. Bricktor is a woven mesh of light galvanised wire prepared in $2\frac{1}{2}''$ wide bands and sent out in coils. Being thin it is easily built into a brick joint with ordinary mortar and can be quickly laid out flat upon a completed course ready for the next to be bedded over it. It should be well enclosed in mortar or it may not be very durable.

567. Exmet is a light form of expanded sheet metal, cut and deformed into diamond meshes like the heavier floor reinforcement. It is made in $2\frac{1}{2}''$, $7''$ and $12''$ widths and coils from 75 ft. to 270 ft. long. The meshes are about $1\frac{1}{8}'' \times \frac{1}{2}''$ and the steel sheets from 24 to 20 Birmingham wire gauge.

Bundles of flat strips are also obtainable in lengths up to 16 ft. All the material is dipped in Asphaltum paint before leaving the works.

568. Hoop iron or hoop steel has been largely employed for bonding strips in brick walls, especially for walls filled with headers and in important footings. It is made in widths from $\frac{3}{4}''$ to $1\frac{1}{2}''$ and of variable gauges. Hoop iron should be preserved by tarring and sanding where employed, or by dipping in preservative solution, but it is now being displaced by the above and more modern materials.

569. Wire net. Ordinary wire net can be usefully employed for bonding purposes. If not in suitable widths it must be cut into strips; it is not then so efficient as the specially prepared mesh.

Materials used by the Mason

570. Stone. Stone is a mineral consisting of an amalgamation of small grains of hard material, naturally cemented together, and rendered strong and dense by the pressure undergone due to its position in the earth.

Stones used by the mason may be practically divided into three classes, viz. granites, sandstones and limestones. There are many subdivisions of these classes, and also other modes of classifying them, but these are only of interest to a specialist in stone.

571. Granites and Sandstones both contain large quantities of "silica" (sand), but in granite the subjection of the stone to much heat during its formation has so changed the character of the whole material that there is no similarity between the granite and sandstone.

The silica contained in granite is in massive "quartz crystals", which form about three-fifths of the bulk, the remainder being felspar and mica in varying proportions. The stone has a strongly mottled appearance, varying in colour from grey to almost black in some varieties, while in others the colour is in varying shades of red. No lamination exists, which is due to the materials having existed in a semi-molten state.

Granite is used for base courses, dressings and pavings, and when broken to a fine aggregate makes an excellent, hard wearing, non-slippery concrete. It might suitably be used for the finished surface of the basement floor to the warehouse, screened as "sand" from broken granite.

572. Sandstones are often composed of grains of silica (sand) cemented together by silicic acid to the extent of 95 to 98 per cent. of their bulk, the remaining materials being small quantities of oxide of iron, carbonate of lime and other unimportant substances.

Sandstones vary in colour from cream and light yellow, to rich brown and red, and in some cases grey and bluish-grey. They are all essentially gritty in nature, though the cemented grains vary in size from very small, to large, rough and sharp units. All are more or less laminated, having been formed by successive deposits in water, but in many cases the laminations are invisible to the naked eye, and in the best building stones the planes of bedding do not seriously affect the attempts of the stonemason to dress it into the required shapes. When fine-grained, of close texture and capable of being freely cut with steel tools, it is called "freestone". In Scotland the term "liver rock" is common, and in the north of England it is named "knell" stone.

Large grained sandstones are very sharp and gritty, but are

seldom strongly amalgamated, and hence may be weak in resisting compression.

Stones which are fine grained, very definite in lamination and easily cleaved, are formed into tilestones (roofing slabs) and provide a good and pleasing, though heavy covering. The poorer qualities form flat-bedded rubble for boundary walls, while good material, not easily cleaved, is employed for the production of "regular coursed" rubble wall stones.

Some sandstones are of an intensely hard nature, irregular formation and knotty appearance when split from the mass. These are used for floor slabs, in footpath paving, and also as paviors for street work.

573. Limestones are an entirely different class to sandstones. They vary largely in character and formation, some being the result of "calcium in solution" being deposited in water, while others are almost entirely due to the deposition of organic remains in water. The former produce fine grained crystalline stones, while the latter consist of accretions of larger grains intermixed with minute shells and fossils. The study of limestones is too extensive to develop here, and we may only note that all true limestones consist almost entirely of carbonate of lime (calcium carbonate) in both the "base" and cementitious matter. As in most minerals, some foreign matter is usually present, sometimes in very small quantities and in other cases forming a large proportion of the mass.

Carbonate of magnesia is the commonest foreign constituent and may form from one-fourth to one-half the bulk, when the stone is called "magnesium limestone". Small quantities of silica, alumina and oxide of iron are also present, chiefly affecting the colour.

Limestones vary much in tint, the useful building stones being mostly cream coloured, though some are of a blue-grey tint. Many hard, dark grey and blue stones are used for road surfacing, being too hard and irregular in form when quarried to serve any other purpose, except as an aggregate for mass concrete.

Other stones are suitable for manufacture into "quicklime", as described in paragraph 675.

574. Comparison of sandstones and limestones. As a class, limestones of suitable texture make good building stones when employed in pure atmospheres, but for town work where smoke and acid fumes are present in considerable quantities, many of them weather badly.

Sandstones are usually much superior for weathering in impure atmospheres, especially the freestones, though they have not the same aesthetic value as some limestones. Many sandstones are stained with iron, which forms strong brown patches due to moisture

and oxidation on the natural faces of faults and cracks in the rock; advantage is now often taken of this and other variations of colour to obtain harmonious combinations which in no way detract from the natural weathering properties of the stones.

575. Properties of good stone. For general building purposes stone should be of fine or medium grain, moderate weight—say 135 to 145 lbs. per cu. ft.—should not absorb water freely, but should be free working and obtainable in blocks large enough for cills, lintols, thresholds and steps.

Its colour and capacity for finish are matters of personal preference, but it must be sufficiently strong and tough to resist spalling and cross breaking when used in exposed positions and for *bearing* purposes.

Descriptions of stones in general use. These will be very brief because the student can only gain real conversance and knowledge by actual examination and tests of typical specimens in the manner suggested in the companion volumes on "Building Science".

Varieties of Stone in General Use

576. Granite. Granite is obtained from Scotland, in the counties of Aberdeen, Inverness, Argyll and Stirling; in England from the counties of Cornwall, Devonshire, Westmorland and Leicestershire; and in Ireland from the counties of Down, Dublin and Wicklow. Large quantities are also imported from Norway and Sweden and from the Channel Islands.

Granites are chiefly coloured in varying shades of red and grey. The best known are Aberdeen (grey and pink), Peterhead (red), Cornish (chiefly grey), Westmorland (reddish-brown), Guernsey (grey) and the Irish varieties from Newry, Dalkey and Castlewellan all of which are grey.

Norwegian and Swedish granites are commonly greenish-grey and the green tint is distinctive of them. The density of granite varies from 165 to 190 lbs. per cu. ft. and most of the material will take a high polish.

Sandstones

Well known English stones are quarried in the counties of Yorkshire, Lancashire, Nottinghamshire, Derbyshire, Cheshire and Gloucestershire. Others, not so well known, are found in Surrey, Sussex, Kent, Shropshire, Cumberland, Northumberland and Durham.

The following brief descriptions include only the best known stones.

577. Yorkshire stones, obtained from the districts around Bradford, Leeds, Halifax and Huddersfield, are excellent stones for

general building, varying in colour from creamy-yellow to yellow and brown. All are very similar to the old *Bramley Fall* stone. They are strong and durable, and vary sufficiently in the grain to suit every grade of work. These stones are used for walling, dressings, steps, landings, paving blocks and slabs.

Nidd valley stone, from *Scotgate Ash*, Pateley Bridge, and from the Harrogate district, is similar, but of the finest quality of freestone, while Wakefield, Whitby and many widely distributed districts produce very good building stones.

578. Nottingham produces white and red sandstones from the Mansfield district. These stones are very largely used and are amongst the best English sandstones. *Mansfield* stone is one of the few sandstones containing a large quantity of carbonate of lime.

579. Derbyshire stones are quarried in the districts of Derby, Bakewell and Ashover. *Darley Dale* quarries, near Bakewell, produce the best known stone; it is hard, strong and of close compact grain and the colour is a pleasant brownish-yellow tint. Some of these stones are difficult to work, and all weather excellently.

580. Gloucestershire produces good stones at Bristol and near the towns of Lydney and Coleford. The stone obtained around these latter towns is known as *Forest of Dean* stone and is a fine grained material, of uniform texture, free working, obtainable in large sizes and in three tints, blue, grey and a dull red.

The stone is particularly suited for steps, paving, templates and the like, because of its strength and resistance to abrasion.

581. Cheshire produces a pleasant warm red sandstone commonly known as *Runcorn* stone; it is subject to great variations of quality and colour and contains many clay holes. The best qualities are artistic and durable in clean atmospheres.

582. Lancashire stones of good quality are quarried near Preston, Lancaster, Rochdale, Burnley and Wigan. Some of them are free-working and some are only suitable for steps and flags owing to their rough and irregular laminations. Many of them are strong and all have been used locally for general building purposes.

The colour varies from yellow to brown and bluish-grey.

583. Scotch sandstones. There are many excellent sandstones quarried in Scotland in the counties of Edinburgh, Dumfries, Linlithgow, Lanark, Stirling, Forfar, Inverness, Caithness, etc.

The best known are from the districts of *Craigleith* and *Hailes*, near Edinburgh, and these stones are considered to be about the best produced in the British Isles. They contain an unusually high percentage of silica, are freestones, and weather exceedingly well.

Some of the stones vary in colour from light grey to white, while that from Hailes is often a dark grey and sometimes almost black.

Closeburn and *Corsehill* stones from Dumfries are also well known in England. Their colour is a varying red and the stone is employed for all general building purposes.

584. Welsh sandstones are not numerous, but good stones are obtained in Denbigh and Glamorgan. Both are suitable for good dressings and the latter for steps and landings.

Limestones

Limestones are quarried in Somerset, Wiltshire, Dorset, Devonshire, Lincolnshire, Cambridgeshire, Derbyshire, Rutland, Gloucester and Yorkshire, and some good stones are also obtained from the north of France. The best known stones are briefly described below.

585. Bath stone, which is one of the most widely used stones, is obtained in the counties of Somerset and Wiltshire, similar stone being obtained over large districts. Some of the best known quarries are *Coombe Down, Monk's Park, Box Ground* and *Farleigh Down.* The stone is of a cream colour; it is soft and easily worked when quarried but hardens on exposure and is most suited for internal work in dressings and carving, though Box Ground stone weathers well externally while being the best of the stones for internal carving.

The architectural appearance of Bath stone is good and its external weathering properties may be improved by the use of a stone preservative known as "fluate".

586. Somerset stones. Other good stones are obtained in Somerset at *Doulting* and *Ham Hill.* The former is a freestone of cream colour and is valued for interior work and carving. Ham Hill stone has a yellow colour and is rather coarse in the grain.

587. Wiltshire stones. Another good stone is obtained in Wiltshire besides the Bath stone and is known as *Chilmark* or *Tisbury* stone. Its colour is light brown and it is valued for dressings and general building.

588. Dorset stones. Two districts in Dorset produce very well-known stones, viz. Purbeck and Portland.

Portland stone is perhaps the most important English building stone, being very largely used for architectural work in London and weathering better than any other limestone. There are two beds producing suitable stone for architectural purposes, viz. the *basebed* and the *whitbed*; the former is of a white or pale cream colour and the latter of a light brown tint.

Purbeck stone, quarried near Swanage, is a very fine grained cream-coloured stone used for internal work and paving blocks. A grey marble is also quarried at Purbeck; it takes a good polish and has been much employed for small columns in church work.

589. Yorkshire limestones. Yorkshire is fairly rich in limestones as well as in sandstones.

Anston stone contains carbonate of magnesia in large quantities and is of a creamy brown tint.

Tadcaster stone is of variable quality, some beds being very good, while others do not weather well; the colour is a dark cream.

Park Nook stone, obtained near South Milford, and *Roche Abbey* stone from near Bawtry, are both fairly well known; they have a variable cream colour and pleasant appearance but are subject to defects and vary in weathering qualities. Roche Abbey stone often turns black.

590. Other stones in general use are: *Ancaster*—Lincolnshire—hard and compact and with good weathering properties; colour, light brown; used for quoins and plinths. *Ketton and Casterton*—Rutland—cream and pink tints, used in many important buildings. *Hopton Wood*—Derbyshire—fine grained, nicely marked fossil limestone, often called a marble because it polishes well; specially fitted for internal work such as chimney pieces in halls and dining rooms. *Beer* stone—quarried near Axminster, Devonshire; *Painswick*—Stroud, Gloucestershire, and *Clunch*—Cambridgeshire—are all considered good and useful stones; the latter is more suited for internal work.

591. French stones. Good limestones have been imported from northern France, the best known being *Caen* stone, which is fine grained and heavy and is specially suitable for internal carved work.

592. Polishing granite and marble. Granite is polished by first reducing the surface to as fine a finish as possible with a patent axe, consisting of a group of thin parallel steel blades bound together, and having sharp edges which can easily be restored by removal from the group for individual treatment. The fine-axed surface is further reduced by rubbing it with fine sand and water under an iron rubber; it is then smoothed with emery powder and finally polished or glazed with putty powder and flannel.

Marbles, after dressing, are reduced and smoothed with sand, then fined with snakestone and finished off with putty powder applied with suitable pads. Dull polishes may be revived by applying a thin mixture of beeswax and turpentine with a flannel, and afterwards briskly rubbing until the turps has evaporated.

For cleaning and polishing, lime water, raw linseed oil and turps may be employed, finishing being done by a pad moistened with methylated spirits.

Note. Stones used for the production of lime. Many limestones are of no use for building purposes, being either too soft and chalky or too hard and brittle to work economically. The former are employed in the manufacture of lime[1] and the latter quarried solely for road metal or as an aggregate for mass concrete.

Mortar for bedding and pointing has already been described, and applies equally to the mason except that light coloured mortars made from clean, light coloured sand and white lime are desirable for jointing and pointing some of the lighter tinted stones.

Materials Used by the Carpenter and Joiner

593. Timber. Wood employed for constructive purposes is the product of growth in the larger members of the class of trees known as "exogens", and is commonly termed "timber". The trunk and branches add to their section size by contributing a new layer of woody fibre, season after season, enclosing, and deposited upon, that already formed, and immediately beneath the protective covering called the bark.

We are only interested here in the nature and disposition of the elements of timber, so far as its capacity for structural use, durability and liability to change its form are concerned.

Most timber is sufficiently durable and suited to constructional work, if of adequate size and used under favourable conditions, but there is a difference in "degree" of suitability, depending upon cost and sufficiency of supply, hence we have been led by circumstances to determine the use of any timber by

(*a*) Its "natural fitness" for an intended purpose.

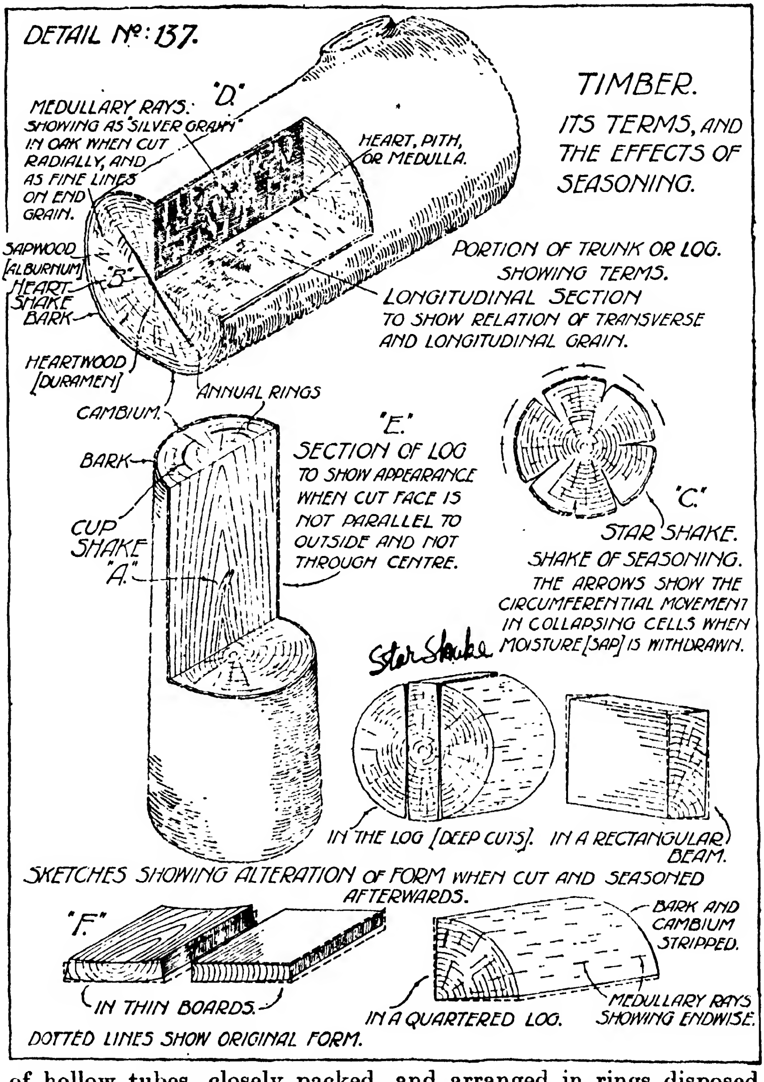
(*b*) Its economic natural production or cultivation, and shipment.

(*c*) The limit of desired expenditure upon, or required "life" of, a structure.

In pointing out later the special and accepted uses of various timbers, we must bear in mind that a combination of the above circumstances has, through years of experience and adaptability, determined these uses.

594. Structure. Before speaking of any special "kinds" of timber, we need to study the structure of the material in a practical way, because it is almost identical in general character throughout the class of trees producing useful building material. The first point of real importance is to learn how the fibrous growth and natural influences cause it to change its form, when cut down and converted into useful sizes.

It is common knowledge that a timber tree consists of bundles of fibre, parallel to the length of its trunk and branches, in the form



of hollow tubes, closely packed, and arranged in rings disposed somewhat irregularly round a common centre; detail No. 137. The centre is a soft "pith", also called the "heart" or "medulla". Each

ring, called an "annual ring", consists of a lighter coloured and softer portion which in some woods is visibly porous, and a darker coloured and denser portion, grown in the spring and autumn respectively. The variation in character and density between these rings is very marked in some woods and scarcely discernible in others, but usually clear enough to distinguish one season's growth from another.

At right angles (normal) to these rings of longitudinal tubes are isolated bundles of cells, penetrating the former in great numbers, and varying much in length. In a cross section (where visible) they appear as groups of lines radiating from the bark towards the "heart" or "medulla" and are termed "medullary rays".

In most tree sections a distinct difference is visible between the timber grouped about the heart, and a rim of material immediately within the bark. The latter is less mature in its growth, being only "partially" developed, containing much more sap and commonly known as "sapwood". The former, grouped about the heart, is wood that has practically reached its full growth and maximum density, contains much less sap than the lately grown wood and is known as "heartwood" because of its position round the heart.

Heartwood, in a tree not overgrown, is the most durable portion of the product. In overgrown trees, and those which have begun prematurely to decay, the wood immediately surrounding the heart shows signs of deterioration and may be noted by discoloration, loosening of the annual rings and radial cracks due to contraction.

Sapwood occupies varying widths of the section, averaging 1″ broad, and is too immature to employ for constructional work. It should be removed in sawing the timber into marketable sizes. Sapwood varies largely in colour, most often being lighter tinted than the heartwood and in some cases nearly white, while in others (chiefly soft woods), having a light general colour, it may be of a greyish-blue tint.

595. Change of shape. When a tree is felled it contains a quantity of "sap", which is distributed through the mass of cells and fibre, keeping these in an expanded condition. Natural evaporation at once commences, and the hollow cells begin to collapse on the withdrawal of moisture and contraction of the fibre; but the structure of the wood causes collapse to take place principally in definite directions, governed by the groups of medullary rays, which are not easily changed in their fibrous length.

Roughly, the following process occurs:

The medullary rays maintain their radial length and try to keep their direction, while the longitudinal tubes between them collapse in the direction of the *circumference* of the rings, tending to reduce

the girth of the trunk. But this reduction cannot take place while the rays maintain a constant radius, except by dividing radially, with the result that splits occur along the length of the tree and across the radial lines of the rays in cross section, at the weaker places of adhesion between rays and longitudinal fibres.

However the trunk may be sawn up into smaller sections, the same nature of main change will always occur; we may state it thus: "timber always tends to become less in the direction of the curves of its annual rings, causing the medullary rays to draw closer together."

Various sections are shown in detail No. 137 at F indicating changes of form during seasoning.

If this collapse be restrained cracks will occur, which increase in size in proportion to the amount of moisture withdrawn and the dimensions of the timber, hence attention must be paid to the following points:

(*a*) Cut down the tree in winter or late autumn when the amount of sap contained is at a minimum.

(*b*) Partially and gradually evaporate the moisture while in the log, then convert by sawing into the required market size.

596. Seasoning. Seasoning is the removal of the fluid portion of the vegetable sap from the material, in order to prevent possible fermentation and decay. If left to natural influences the fluid evaporates at a rate dependent upon atmospheric conditions, *e.g.* dryness, wind and sun. Wind and sun cause rapid surface drying, intensifying the tendency to crack by speedy contraction of the surface while the interior is very little affected.

Slow, protected seasoning gives the best results, for, by slowly increasing the stress and strain due to contraction, flaws are largely avoided.

Seasoned timber (once adequately divorced from its natural fluid and with dry cell walls) will still be absorptive, expanding and contracting continually with changes of humidity and temperature, the change being, of course, very much less than the initial change of seasoning.

A seasoned timber, therefore, kept subsequently in damp, unfavourable conditions, is not necessarily *dry* and fit for important construction; further, as every timber when wrought to a fresh surface dries and changes its form a little further, it is usual, after machining the material to the required size for framing, to allow for a second seasoning, by storing in a loosely assembled condition for a minimum period of two to three months.

For *Carpenters' Work*, well seasoned material is necessary, while for *Joiners' Work* it must be perfectly seasoned and dry, if it is to remain of constant form after framing together for interior use.

It is important to remember that it is no use employing seasoned and dry material, accurately prepared and well finished, in a partially completed building with a humid, perhaps *saturated* atmosphere due to drying plaster.

Detail No. 137 shows the changes of form which might take place in various pieces of material including a complete log and sections cut from several positions in the tree.

Defects in Timber and Decay

Timber is subject to many defects, some of which are defects of growth and incipient decay, while others are due to seasoning and to the condition of storage. The more important of these are described below.

597. *Cup Shakes.* A separation between the annual rings is called a cup shake. It may extend over a considerable length of one ring, or break across some rings and continue along a different one; see detail No. 137 at A. The defect is probably caused by sudden contraction under changes of temperature assisted by the bending and twisting action due to wind pressure; it may seriously hinder economical conversion unless confined to a small surface.

Heart shakes. Clefts or cracks, widest at the centre, diminishing outwards and running lengthwise of the fibres, as at B in the detail. Due to shrinkage near the heart of over matured trees. Generally a sign of incipient decay.

Star shakes. Splits running lengthwise but widest at the circumference, due to the collapse of the outer cells in seasoning, as shown at C.

Twisted fibres. Caused by constant tendency of the trunk of a tree to twist under the action of a prevalent wind; may be seen clearly in many growing trees. When converted into planks or boards, seasoning causes warping and further twisting in the direction of the twist of growth.

Rind falls. Irregular and somewhat loose growth caused by the fibres gradually overlapping a wound or lopped branch.

Upsets. Injuries to the fibres running transversely and amounting to discontinuity causing great transverse weakness. Due to crushing on the compression side when bent in a wind and accentuated in felling.

Foxiness. Discoloration in over matured wood. A sign of decay; developed by unventilated storage in transit.

Druxiness. A decay showing as white patches and streaks.

Doatiness. Peculiar to beech, American oak, birch and alder. A speckled light coloured patch indicating local decay; becomes rotten if exposed to wet.

Waney timber. Absence of sharp angles due to over economy in conversion; shows rounded angles, with the bark or outer fibres of the sapwood not removed.

598. Dry rot. A most troublesome form of decay and destruction of timber due to the growth of a fungus, which germinates and spreads rapidly, throwing out spores which alight on surrounding material, develop and attack it.

Once commenced, dry rot extends rapidly, the fungus sending out long strands which spread over other timber, walls, plaster, etc., drawing their sustenance from the timber upon which the roots have taken hold.

The timber is often infected soon after felling and shows by red and brown stripes in the timber when opened up in the process of conversion.

Imperfect seasoning and use in an atmosphere which is warm and humid assist the growth and development. Lack of ventilation tends to this condition. Spores from existing fungi are easily transmitted like any germs of infection by currents of air or by human or animal contact.

Attention should be paid to ventilation of constructional timber and ends of joists, wall plates, studding, wood slips and pallets should not be enclosed in walls.

It is difficult to eradicate dry rot, but thorough cleaning of infected and adjacent parts, coating with hot lime and afterwards spraying with acrid preservatives will usually prevent further spread. Carbolineum, creosote and other *tar products* are most effective.

599. Wet rot is caused by and can only take place in the presence of excess moisture in the open air. The carbon compounds in the timber are oxidised and transformed into CO_2 and the hydrogen into water.

Wood Preservatives, other than Paint

600. Creosote is an oil distilled from tar, and freed from ammonia and employed, by impregnation, for the preservation of timber to be exposed to destructive elements.

The timber must be well seasoned, wet and sap expelled, and the decay of the remaining albuminous matter prevented or retarded by forcing the oil into the material. The oil is heated in large tanks, the timber immersed, and pressure up to 160 lbs. per sq. inch applied and relieved alternately. A reduction of pressure below that of the atmosphere releases air from the pores and assists the oil to take its place when pressure is again applied. The method is known as Bethel's process.

601. Use of chemical fluids. Many chemicals are employed for impregnating and indurating the walls of timber fibre. Amongst these are Sulphate of Copper (Boucherie's process), Mercuric Chloride (Kyanizing), Carbolic and tar acids (Blythe's process), Zinc Chloride (Burnettizing).

The fluids are compelled to travel lengthwise of the grain to ensure speedy and thorough impregnation.

602. Carbolineum now known as "Peterlineum" is a preparation similar to creosote but thinner and intended to be applied while hot, in successive coats, to exposed timber framing, *e.g.* wood gutters, posts embedded in the ground, etc.

Solignum, Sylvadure, Pilcher's Stop rot and other preservatives are either oil or tar stains which penetrate wood fibre freely and are efficient for their purpose when properly applied.

Timbers in Common Use

In the following brief descriptions of common timbers students should note that all these apply to average specimens. All timbers vary much in appearance and characteristics, and only by oft-repeated examination can one hope to become conversant with them.

Experiments conducted in a building laboratory,[1] together with examination of stocks of sawn timber and the same woods employed in finished work, will provide the surest means of gaining knowledge.

603. Classification. Building timbers are roughly divided by users into hard woods and soft woods according to their difficulty or ease of working with ordinary tools. By this means pitch pine is sometimes called a hardwood and basswood a soft wood; actually, they belong to different natural classes.

The more acceptable classification is to name the divisions according to the kinds of trees from which they are obtained. Amongst building timber trees, there are two easily divided classes, viz. *Conifers*, or needle leafed evergreen trees, bearing cones; and *Broad-leaf* trees, having flat, broad leaves which are shed annually.

Conifers include: spruce, fir, pine, cedar and cypress.

Broad-leaf trees include: oak, ash, elm, mahogany, teak, walnut, lime, etc.

Reference in detail will only be made to the timbers from these trees which are in common use.

Coniferous Woods

604. Spruce. The timber from these trees is a tough, elastic material, nearly white in the best specimens, but often containing numerous hard, light coloured knots which make it difficult to work

[1] See Manson's *Building Science.*

when dry and well-seasoned. The wood is practically odourless, but pockets of resin are frequent; the annual rings are fairly distinct, but the longitudinal grain not very definite. A fine glossy finish can be obtained on good timber.

The wood is grown in Norway, Sweden, Russia and America, and in the English market is called *white deal* if imported from the Baltic countries and *spruce* when from America. Much of the American timber is knotty and tough in the fibre, but silver spruce can be obtained in large pieces of considerable length, with few knots or other defects except stains.

All spruce and white deal is liable to warp badly, especially if cut into thin wide boards.

The average weight is about 32 lbs. per cu. ft. and the material is obtainable in various market sizes from 4″ × 1″ to 11″ × 4″.

Uses: Floor and roofing timbers and partition framing in cheap work. Flooring boards, paving blocks, shelving and storage fittings. Should not be employed for joinery except in narrow skirtings and door linings, and rough grounds and stair tread sin ordinary dwellings.

605. Fir. The Scotch fir or Northern pine tree produces the most commonly used timber for general construction; the wood is usually known as *red* or *yellow deal* (or fir) amongst practical men, but in technical and professional work northern pine is the term more often employed.

Northern pine is heavier and stronger than spruce though not so flexible; it has a faint resinous smell which is most noticeable when freshly sawn. The colour is a brownish-yellow, deepening on exposure to a reddish tint; the wood contains a fair number of knots of a darker colour and resinous nature and is much easier to work than spruce. Its annual rings are clear and the grain distinct.

This timber is grown in Russia, Prussia and Sweden and is imported in large quantities. The tree is also common in Britain but not cultivated specially for its timber.

The material is obtainable in square balks, but is chiefly imported as sawn timber in various grades and sizes having a maximum section of 11″ × 4″ and lengths of 26 to 30 ft. Its density is about 35 lbs. per cu. ft. for matured timber.

Uses: Roof and floor timbers, partitions, flooring boards and blocks, external doors and frames, window sashes and frames, eaves gutters and all joinery in ordinary dwellings.

606. American yellow pine. This is the most suitable soft wood timber for internal work of good quality and is very generally employed. It is also known as "Canadian white pine", "Quebec pine", and "Weymouth pine".

The colour when newly wrought is a pale yellow ochre; there is no distinct surface grain, though the annual rings are fairly clear. The finished surface from a sharp tool is soft and luminous, showing numerous fine resin cells which become very distinct on exposure due to chemical change and absorption of dust—they appear as short dark hair lines parallel to the grain; may be distinguished from abnormal specimens of yellow deal by this feature and also by the density which averages about 28 to 30 lbs. per cu. ft., though some of it is much lighter in unit weight.

Grown in the north-eastern states of U.S.A. and in Canada and shipped from Halifax, St Johns, Quebec, etc.

The wood is obtainable in wide, long pieces and is invaluable for panels, moulded joinery and engineers' pattern making, because while soft and easy to work, it will finish to fine sharp arrises and if properly seasoned will maintain its form better than any other timber. It is, however, subject to cup shakes and dead knots.

Uses: All good internal work which is to be painted such as panelled doors, linings and finishings, cupboard fronts, drawers, stairs, skirtings, etc., and also for the wood patterns employed in metal casting.

Canadian red pine is very similar in appearance and character to yellow pine and is employed for the same purposes.

607. Pitch pine. The timber imported under this name is the product of several American pines of a highly resinous character, all having wide annual rings and strong grain. The colour varies much but is generally a golden yellow with brown markings.

The wood is heavy and strong, obtainable in large sizes, and is imported in large quantities. Its density varies greatly but averages 46 lbs. per cu. ft.

Because of its strength and rigidity it is largely employed for both permanent and temporary carpentry. In floors and roofs it is used for members which exceed $11'' \times 4''$, viz. the largest usual market size for northern pine; in temporary work, it is employed for posts, dead shores and heavy raking and horizontal shores, and it has been largely used for piling.

The better material, having a rich colour and softer grain, is in considerable demand for joinery work in public buildings and especially in schools and churches. Special care is necessary in selecting and seasoning timber for joinery because the shrinkage is excessive and some materials warp badly; with care, however, many satisfactory examples have been carried out. The chief objection to pitch pine, when varnished to show and possibly emphasise its original colour, is the crude, harsh effect of new work.

Much pitch pine work has been stained in warm green or rich

brown tints and then varnished. If the stain is transparent the grain shows clearly and usually produces a good effect. Ordinary paint cannot be used successfully on pitch pine especially in external work, the more resinous part of the grain quickly showing through.

Uses: Floor and roof timbers, shores, posts, piles; internal joinery in public buildings and school furniture; flooring boards and blocks.

608. British Columbian Pine, Douglas fir or Oregon pine. This timber is intermediate in its appearance and characteristics between northern pine and pitch pine. It is wide in the grain, free from knots and defects, shrinks excessively, is brittle but rigid, and is obtainable in unusually large sizes. Its density is less than pitch pine and averages about 40 lbs. per cu. ft. The wood is employed chiefly for carpentry, such as large tie beams and floor girders, though the finer qualities have been used in joinery and furniture. This timber varies considerably in grain and density and is not so reliable as pitch pine. It shrinks and warps considerably. Its use has increased in recent years, however, owing to the determination to use Colonial and Empire timbers in preference to foreign products.

609. Other timbers from coniferous trees are: *Kawrie* or *Cowrie pine*, from New Zealand, a fine silky wood of pale straw colour, with a lustrous surface when wrought; a most useful joinery wood, free from defects and in large sizes. *Sequoia* or *Californian red pine*, a very soft, short grained timber, obtainable in abnormal sizes, easy to work but so soft as to be easily damaged; should be used chiefly for panels and flat work with plenty of allowance for shrinkage, which is excessive in breadth and also appreciable in length—an unusual characteristic. *Cypress pine* and *pencil cedar* (Australia). The former obtainable in large pieces without defects. Good for joinery and cabinet work but requires to be well seasoned.

For Empire timbers of more recent introduction see par. 616.

Broad-leaf Woods

610. Oak. The commonest English timber and one of the most durable and beautiful woods known. Grows also over the whole of Eastern Europe and large areas in North America and Canada. It is used extensively for carpentry, joinery and cabinet work of the best kinds.

Oak possesses the unusual feature of strongly marked medullary rays, which in the end grain are often more prominent than the annual rings, and when cut lengthwise of the timber through a radial end section the numerous groups of rays are exposed sectionally upon the surface, forming beautiful lustrous and irregular patches known as "felt" or "silver grain," and indicated at D in

detail No. 137. When cut to show the silver grain the timber is highly prized for joinery and cabinet work in broad framing and panels.

If cut as shown at E, in a direction not parallel to the side of the trunk and clear of the pith, the surface grain indicates the lines of growth and in trunks which are not straight may be very attractive in appearance, although the boards are liable to warp as at F.

English and continental oaks are usually of a rich light brown colour, with distinct annual rings and clear grain, the distinctness arising chiefly from the visibly porous character of the spring wood. The density averages about 50 lbs. per cu. ft.

American oaks vary in colour, some being a light brown, others nearly white or with a reddish tinge. The latter kinds lack the beauty of European oak and the former have not the richness of colour and variety of shading of English oak.

Austrian oak is usually of a rich colour, with wide annual rings due to quick growth. It is straight grained and easy to work, of lighter unit weight than English oak and often specially cut to show the silver grain. Any oak so converted is known as Wainscot.

Japanese oak has been imported into England in considerable quantities. Its colour is rich and darker than most oaks; the grain is straight, the wood easy to work, but the silver grain is not so distinct nor so irregular as English and continental oaks. It is light in weight and lacks strength in consequence.

Australian silky oak is a fairly new importation. The colour is much richer and darker than in other oaks and the grain full and unattractive except when used as a veneer amongst other coloured woods of an ornamental character.

Oak corrodes iron and steel, owing to the gallic acid it contains. It is extremely difficult to season and is very liable to warp unless cut radially from the log.

English oak is tough, strong and elastic, irregular in grain and extremely durable under nearly all conditions.

Uses: Carpentry in floors and roofs, flooring boards and blocks, external doors and frames, cills to window frames and sashes, porches, joinery and furniture for banks and public buildings, stairs, balusters and handrails.

Oak may be given a mature, aged appearance by exposing it to the fumes of ammonia in a closed chamber. American red oak is not affected in this way, the best varieties for the purpose being British and Austrian oaks.

611. Mahogany. Obtained from the West Indies, in the country round the Gulf of Mexico and the Isthmus of Panama. A kindred timber also grows in Africa and is now largely imported.

The wood has a bright reddish-brown colour and varies much in tint and depth of colouring and also in the strength of the grain. End grain is almost uniform in colour and the annual rings are only distinguishable by the porous rings of spring wood.

The surface grain is often very wavy, softly shaded and beautifully figured. Some varieties are soft, straight grained and easy to work, while others are stringy or woolly in the fibre and difficult to finish; with care, however, most varieties take a high finish and a good polish. Mahogany varies much in density, the average being about 40 lbs. per cu. ft.

The most valuable mahogany is obtained from Cuba and is known as Spanish mahogany; the pores are filled with a chalky substance, which is characteristic of this variety.

Honduras mahogany is also considered of good quality. It is known as "Bay-wood", has a rich colour, and is easy to work.

Uses: High class internal joinery, fittings for banks and public buildings, such as counters, vestibule screens, stair newels and handrails; also for bath tops and enclosures, W.C. seats, etc. It is not suited to external work unless well polished or protected by varnish, as it bleaches and deteriorates rapidly if exposed to the weather. It has been employed considerably for polished shop fronts, and is largely used for small and intricate patterns.

612. Teak. Obtained from India, Burmese peninsula and some of the East Indies. Colour varies from a greenish-brown when newly cut to a rich brown after exposure to the atmosphere. The density is about 48 lbs. per cu. ft. The grain is straight and uniform and only varied by the porous part of the fibres.

Teak is very strong and rigid, though it is brittle and splinters readily at the edges. It is the best of all timbers for resisting insects and chemicals, and keeps its form exceedingly well when worked and framed together. Teak needs little or no seasoning, as very little shrinkage occurs.

It is easily recognised because of its distinctive smell, due to an aromatic oil of a resinous nature which it contains; this oil preserves metal fastenings and repels insects. The pores also contain a large amount of grit which blunts tools very quickly; apart from this it is not difficult to work.

Uses: External doors and frames, cills to windows, shop fronts and any first class external work. Table and bench tops in chemical and physical laboratories, dyehouse and stable fittings, etc., and also in shipbuilding and ship joinery.

613. Walnut. Grown in Europe, America and Australia.

European walnut is a rich brown colour and not so dense as other

kinds. American walnut is of two kinds, black and white; the former is most common and is largely imported.

The European wood is chiefly obtained from Italy and around the Black Sea. Its density is about 42 to 44 lbs. per cu. ft. but it is not very strong and is most suitable for joinery and cabinet work; rough burrs form on the trees which are artificially encouraged, and when large enough are cut into mottled veneers known as burr walnut.

The American black walnut is in very common use and is employed largely for furniture work and ornamental joinery. It is very dense, averaging 55 lbs. per cu. ft.

Most walnut is easily seasoned and may be relied upon to keep its form, hence its value to the cabinet maker.

Uses: Newels and handrails, furniture, bank and office fittings, shop accessories, etc.

614. Ash, Elm, Beech, Birch and Sycamore are not much employed in builders' work. *Ash* is chiefly employed for tool handles, wheel spokes and parts requiring elasticity. *Elm* is employed for piles, and for wood-turning—also for rough furniture and external weather boarding. *Beech* is used for planes and tool handles, mallets, tee square blades and some cabinet work. *Birch* is often used for stair newels, handrails, etc., where smoothness is particularly desired. It is frequently stained to imitate other woods, such as mahogany and walnut. *Sycamore* is a clean white timber suited to table tops, butchers' fittings and cutting blocks, and materials employed in cooking such as bowls, spoons and turned work. Both beech and sycamore are useful for wooden screws, *e.g.* vices and hand screws.

615. Basswood or American white wood. The original timber under this name was commonly known as "canary wood", being of a bright yellow or greenish-yellow colour; this wood is the product of the tulip tree and is very soft and easy to work. It resembles the coniferous woods in character and is obtainable in large sizes.

Several other timbers are now very commonly mixed in shipments of white wood, including the American lime and yellow poplar or cotton wood. These latter are tougher than canary wood and do not attain any great size.

The various timbers shipped as basswood are all useful materials, working to a bright finish and particularly suitable for staining and polishing.

Uses: Wide panels for internal doors and framing, cupboard tops, cheap counters, screens, cabinet work and drawers.

616. Colonial and Empire timbers. During recent years the importation and use of Colonial and Empire timbers have grown rapidly.

Space does not allow of detailed descriptions of these timbers but the following notes will draw the attention of the reader to the timbers which are available in addition to those already mentioned in the preceding paragraphs.

For Constructional Work and Joinery

Canadian Red Pine (Quebec Red Pine). Has a reddish-yellow colour. Used for joinery and general building. Harder than yellow pine. Seasons well. Durable except when in contact with damp ground.

Columbian Pine. Of the same family as Douglas Fir and Oregon Pine. All these woods are included in the modern marketing term—British Columbian Pine.

Obeche (African Whitewood). Soft and useful for joinery and fittings. Comparable to some of the poplars. Obtainable in large sizes.

Opepe. Fairly hard and heavy. General construction—flooring and joinery. Polishes well and takes paint freely.

Red Gum (Sweet Gum—Satin Walnut). For interior finishings, mouldings and plywood.

Western Hemlock. Decorative. Selected material for interior fittings, panelling and flooring. Common grade used also for temporary shuttering and trench linings.

Ornamental Woods—Used for Veneers etc.

African Mahogany, Ash (burrs), *Australian Silky Oak, Australian Walnut, Black Bean, Indian Laurel, Queensland Maple, Italian Walnut, Indian Silver Greywood, Rock Maple, Santa Maria,* and many others.

These ornamental woods are usually cut into thin veneers—either circumferentially from the log or flat sawn according to the grain effects required. They are largely used as surface finishes to plywood for panelling and for the modern flush-faced doors.

Plywood and Plymax

617. In modern work a large amount of *plywood* is used. It consists of an odd number of thin sheets or veneers, glued or cemented together with the grain alternating in opposite directions and assembled in sheets of large size. The veneers average $\frac{1}{16}''$ each in thickness and three or five veneers are usually assembled

giving a thickness of $\frac{3}{16}''$ or $\frac{5}{16}''$, and having the grain on the two faces in the same direction.

Occasionally the middle unit is thicker than the others and can scarcely be called a veneer.

The veneers for facing the sheets are generally cut circumferentially from the log and while the grain appears somewhat unnatural, it is often attractive.

The object of the use of plywood is to gain strength and reduce weight.

Plywood is manufactured in large quantities and can now be obtained in high grade material and of dependable quality. It is made of all kinds of home grown and colonial and empire timbers and often surfaced with beautifully marked and naturally coloured veneers.

Plymax is a trade name used by Venesta Ltd. for plywood covered with a thin plate of metal, which may be galvanised steel, copper, gilding metal, monel metal or stainless steel.

Plymax may be faced on one or both sides, and is firmly cemented and pressed, under steam heat and pressure, over the whole of the surface of the sheet.

When faced on both sides, the sheet or unit cut from it (and in the form finally to be used) has the edges sealed by turning both the face sheets over slightly at the edges upon a narrow filling strip, and soldering the edges upon the strip. Double faced plymax is wonderfully rigid when only $\frac{5}{16}''$ thick. It is used largely for partition slabs or panels in lavatory divisions, hospital and college cubicles, and the like. For external work such as notice boards, advertising hoarding and similar purposes it is very durable and suitable.

The material is also treated and finished in various bright colours, arranged in marginal or other patterns, for doors and fittings in cafés and cinemas.

The use of these materials will increase considerably with the modern development of simple and severe forms of architectural design.

The term "armoured plywood" is now being used for metal covered material, and is being produced by other firms especially in the more ornamental metals. Tucker's *armoured plywood* and also *armoured fibre board* are well known.

Armoured plywood has already been mentioned in connection with partitions.

Uses: Panels for doors, curved work built on blocking, surfacing for partitions and screens, flush doors, wall panelling etc.

Alder, Columbian pine, Gaboon mahogany, silver birch and common red birch are much used for plywood, while oak, walnut and other veneers are employed as facings for special purposes.

618. Blockboard. While blockboard might be considered under the heading of patent boards referred to in the next paragraph, it has now become so important in its use for flush doors that special reference is necessary.

It consists of small timber sections cemented edge to edge and covered on each face with a large sheet of thin material—up to $\frac{1}{8}''$ thick—similarly cemented. It is obtainable in large sheets.

For door construction it is used in an overall thickness of 1″ if required for small light doors such as cabinet work. For house doors and the like it is made up of two thicknesses of $\frac{3}{4}''$ blockwood with a $\frac{1}{8}''$ binding sheet of material between the two, and faced as before described. The edges of the doors are stripped with $1\frac{3}{4}'' \times 1''$ double tongued oak strips, or with thinner mitred strip coverings.

A solid door with plain faces is thus formed, known as a flush door. The doors may be of deal blockwood with alder or birch interleaves and facings, and may also be specially veneered with one of the ornamental veneers mentioned in paragraph 616. The flush door may thus be prepared either for a painted or a polished finish.

Blockwood is dependable if the strips are rift sawn—with the annual rings of the timber at right angles to the face—and in any case the building up from numerous strips has a tendency to correct any inclination to warp and twist.

It is suitable for blackboards, large decorative panels, partitions etc. where rigidity and dependable form are required.

Patent Boards

619. Panels, and surfacing as a substitute for plaster, are often made of patent materials such as *compo board* and fibre sheets.

Compo board consists of strips of soft wood glued edge to edge and covered with thin millboard; the others are preparations of vegetable fibre, either compressed for hardwear, or of loose cellular structure and in thick pieces for insulating purposes. Fibre sheets vary from $\frac{1}{8}''$ to 1″ in thickness.

Asbestos-cement sheets are available for external sheeting and have also been used as panels to hardwood doors with a view to obtaining fire resistance.

As most of these materials have a somewhat rough and absorptive surface they should be prepared with a matt surface and finished in flatting paint or patent distempers.

Materials Used in Fixing Woodwork

620. Nails and screws were treated in some detail in Vol. I.

Bolts and nuts were also described in Vol. I, but as they have a special use in steel construction they are further treated in Paragraphs 148 to 151. The metal employed in their manufacture

may be wrought iron or mild steel. Straps for clasping roof members, drawing and holding floor timbers, tightening up partitions and for converting wooden members into reliable tension bars are all made of wrought iron. This metal is described in detail in the Chapter on Materials in Vol. III. Examples have been shown in Vol. I and occur in numerous details in this volume.

Materials Used in Patent Partitions

The materials employed in partition blocks are light porous brick, terra-cotta, glazed firebrick, concrete blocks, plaster slabs.

621. **Porous bricks.** These are made from light brick earths which are moulded to hollow forms with diaphragms, soundly burnt and finished with rough surfaces to give a key for plaster.

Some bricks are rendered lighter by mixing the earth with a small percentage of straw, sawdust or other combustible material which burns out and leaves lighter blocks; this process is more applicable to the solid forms than to hollow moulded blocks.

622. **Terra-cotta** is the name given to material made from the finer and more refractory brick earths, being carefully selected, mixed and prepared. When used for partition blocks—unless the natural surfaces are to be exposed—there is no need for a good finish, but the material described naturally gives a good surface and requires serrations or dovetail grooves to key the finishing plaster where desired. In any case the edges to be bedded and jointed should be serrated, joggled, or tongued. Terra-cotta is highly fire-resisting and is much preferable to the porous block of the same thickness.

Terra-cotta is much used for first class facings to important buildings where stone is not easily obtainable, and lends itself to the production of mouldings and relief work, though it often lacks aesthetic value except where the colour, treatment and design are entirely suitable.

623. **Glazed firebrick.** Partition bricks of white glazed or enamelled firebrick are in common use for good sanitary work. The firebrick is made from a highly refractory clay and the special blocks made by the Leeds Fireclay Co. Ltd, are fine, close grained material, which would be highly sanitary apart from the glazing.

Several special partition blocks are made both in plain unglazed fireclay and in white glazed and ornamental finishes. The glazing is usually one of the enamels referred to in paragraph 672.

624. **Concrete blocks and plaster slabs.** Partition blocks of concrete are desirably light, but must be sufficiently strong and fire-resisting. The matrix should be portland cement with fairly fine sand and the coarse material either coke breeze, pumice stone, light

clinker free from sulphur, or a light and porous broken brick. Some firms employ patent aggregates which are light and specially fire-resisting.

The concrete need not be dense so long as the materials are satisfactory for fire-resistance and strength, and the blocks are usually cast hollow if more than 4″ thick.

Where the aggregate is coke breeze the faces of the partition should be rendered with portland cement plaster.

The lighter and thinner partition blocks are more usually made of plaster. The matrix is plaster of Paris in some form and this is used to unite either a light aggregate or a coarse sand.

Ground clinker makes a good aggregate for this purpose.

Materials Used by the Slater and Roof-Tiler

625. Slates. Slate is the name given to a hard natural rock which will readily split into thin layers and is sufficiently impervious to resist continued contact with water.

True slate is an exceedingly fine grained clay rock which has been changed in character by exposure to heat and pressure, until its original beds of deposit are no longer the weaker planes as in many sandstones, but have been almost effaced by side pressure, which has caused the rock to cleave easily in some direction other than the natural bed.

626. Cleavage. The planes along which true slate splits so readily are known as "cleavage planes" and by some the term cleavage is applied solely to this peculiar property of slate. We have used the term in its general meaning—to split, open, or sever—and in this way have referred also to the production of stone slabs by cleaving sandstone rock which occurs in thin natural layers. It should be noted that the sandstone rock may only be cleaved along the planes of natural lamination and have no shear cleavage like true slate.

True slates are obtained from many parts of Great Britain; the greatest supply is from North Wales but slates are also quarried in considerable quantities in Cornwall and in smaller quantities in Westmorland, Perthshire and Aberdeen.

Norwegian and American slates have also been imported.

627. Colour and tests. The colour of slate varies from grey to dark blue and purple, and many varieties are multicoloured.

It used to be considered that variation in colour indicated a bad quality of material, but this is a mistaken idea so long as the slate is sound; such slates can be employed with great artistic effect.

Slates are tested for quality by their thickness, clean smooth cleavage, toughness to allow of holing for nails, and resistance to

water. A good slate partially immersed in water should not absorb water to any appreciable extent above the water line. When fully immersed in water for ten hours its maximum absorption should not exceed 1 per cent. by weight. It should also give a clear ring when struck with the knuckles and when breathed upon or otherwise rendered moist, should not emit a clayey odour.

The thickness of roofing slates varies from $\frac{3}{16}''$ to $\frac{5}{16}''$, the best qualities being the thinner, but it should be noted that light, thin slates lift and rattle in a wind, and require a steeper pitch to ensure security.

628. **Weight of slates.** Slates are usually sold by units of 1200 slates, which are called a "thousand" in the slate trade, and referred to as one M.

Weight and Covering Power of Slates in Common Use

Name	Size	Weight of Seconds Quality per M	Covering power when laid to a 3" gross lap
Ladies	16" × 8"	$1\frac{1}{2}$ tons (average)	48 sq. yds.
Countesses	20" × 10"	$2\frac{3}{8}$,, ,,	78 ,, ,,
Duchesses	24" × 12"	$3\frac{1}{2}$,, ,,	116 ,, ,,

If laid to a 4" gross lap, countess slates cover 74 sq. yds. and duchesses 111 sq. yds.

The density of slate rock varies from 165 to 180 lbs. per cu. ft.

629. **Welsh slate** is one of the best known and is very dependable in quality. Its colour varies chiefly from blue to purple, though green and red slates are obtainable; the best Welsh slate cleaves to a fine surface in thin layers suitable for roofing purposes, but where cleavage is not perfect, slabs for other purposes are obtained.

The best known varieties are Bangor, Velinheli (Merioneth) and Penrhyn (Carnarvon).

630. **Westmorland slate** is somewhat rougher than Welsh, but very strong and durable. The slates are a dull green colour and are obtainable in large sizes. They have been much used in the north of England on account of their colour, which harmonises well with sandstone structures.

631. **Cornish slate** is also rougher in texture than Welsh and when made into roofing slabs is thicker and heavier.

The slate quarries at old Delabole produce roofing slates of rough texture in beautiful shades of green, mottled reds and greenish-grey, the latter being the main product. This slate is strong, durable and non-porous and is largely cut into random sizes for irregular coursing. Ridge rolls, shelves and slabs for special purposes are also prepared. Old Delabole slates increase in popularity.

632. Scotch slates weather very well but do not cleave so truly. Their rough appearance is not objectionable and they are largely employed for roof coverings in Scotland.

633. Tilestones or greystone slates. These are thin slabs of stone ¾″ or more in thickness and usually cleft from a thin bedded sandstone rock. They are cut in irregular sizes and laid to a variable gauge.

Tilestones are very suitably employed as coverings to stone buildings in country districts; they weather to variable tones and harmonise well with their surroundings. In some parts of the north of England they are called grey slates and are still in use in Yorkshire, Derbyshire and other northern counties.

The chief objection is the great weight of the covering which varies from 18 to 24 lbs. per sq. ft. of roof surface and therefore requires heavy timbers. On the other hand, this covering is well suited to resist gales of wind in hilly moorland districts.

Roofing Tiles

The tiles in common use are plain tiles and pantiles, though several patent forms are employed and also the Italian pattern.

All the above are made from carefully selected and prepared earths in a similar manner to bricks.

634. Plain tiles. These are chiefly made 10½″ long by 6½″ wide and ⅜″ to ½″ thick, though some modern tiles are larger. They usually have two nail holes and are often provided also with nibs projecting from the back upper edge by which they are hung to the laths. All plain tiles are made concave on the bed in the direction of the slope to enable the tails to bed closely and to intercept wind as much as possible.

Many qualities and varieties are on the market and the object of the manufacturer in producing them may be one (or more) of the following:

(*a*) To obtain an impervious covering.
(*b*) To ensure a good uniform colour and smooth surface.
(*c*) To create a desirable surface texture and colouring.

Sufficient imperviousness is required in all roofing tiles, but this does not necessarily mean a hard looking, semi-glazed finish which is so often accompanied by a striking red colour, retaining its strength and contrast for a long time.

Such tiles serve well as coverings and may be much appreciated in towns where tall buildings with hidden roofs are to be covered, because they are effective and waterproof. They also resist the accumulation of soot and dirt to a large extent and thus appear

fairly clean where fully exposed to view. Most of these tiles are made by the semi-dry process and are die-moulded like bricks under great pressure; hence their density and impervious qualities.

Tiles with sanded faces, mellowing with age from the bright red to a warm variegated brown, are excellent for suburban use; the body of such tiles should be of good, well-tempered clay, and the sanded face well fused to the slab. If made from sandy clay and not well burnt, these tiles are liable to be porous and are easily damaged by frost.

Metallic tiles are available in some districts being of a dark purplish-red tint with well vitrified faces. Much variation of tint occurs and often produces pleasing colour effects. These are much preferable to the uniform hard red tiles, from an architectural point of view.

Artistic tiles are also manufactured with a view to obtaining either a multi-coloured face or a face of rough texture and varying tint. A notable tile of this kind is made at St Helens from the same shale as rustic bricks. It is prepared in blocks which are wire cut to a rough surface. The density, composition and soundness of burning make these tiles impervious and durable while the appearance of mature age is conveyed by the blend of tints and subdued colouring.

Another very satisfactory tile with artistic qualities is made at Reading. Students should note that such tiles as these are only satisfactory in rural and suburban districts where the atmosphere is not so smoky and polluted as to obscure the tones by soot and dirt.

Many forms of artificially coloured glazed "patent tiles" are available.

Plain tiles of fair quality are made in many districts where bricks are produced.

Various shapes and sizes of tiles are illustrated in detail No. 98.

635. Cement tiles. Large quantities of roofing tiles are now manufactured from very fine concrete, and are known as cement tiles. They have become so important that a British Standard Specification has been drawn up to assist in improving and standardising their form and quality.

Many of these tiles are artificially coloured.

636. Pantiles. These differ from plain tiles, being bent to a flat S shape. They are made by preparing flat slabs of clay which are then bent to shape over a special mould. A single hanging nib is generally provided; see Vol. III for applications.

Most pantiles are hand made from a poorer class of earth than plain tiles, though there is no reason why this should be the case,

except to confine their use to a cheap covering. They are largely used in agricultural districts and the common size is 14″ × 9″ × ½″.

637. Hand made tiles. Hand made tiles of any kind have the advantage that they are not so mechanically perfect as machine made tiles. When made from plastic clays, after moulding and partially drying they are very liable to pull out of shape as the clay contracts, often cracking and becoming faulty. To correct this tendency the drying tiles are examined and faults rectified by dressing the tiles with wooden beaters.

Slating and Tiling Nails

638. These are round, disc-headed nails of iron, copper, zinc or composition, 1¼″ to 2″ in length, having thin points, somewhat similar in form to clout nails. They are illustrated in Vol. I.

Iron nails are employed in cheap work; to prevent oxidation they need preservative treatment, which is chiefly done by dipping in hot oil or by galvanising. Oxidation will ultimately occur with all iron nails.

Copper nails resist oxidation, but are soft and easily bent in driving. They are initially expensive and wasteful in use and also deteriorate in strength.

Zinc nails are weaker than iron, but stiffer and more satisfactory than copper. They resist oxidation satisfactorily and are in common use.

Composition nails are the best obtainable, being an alloy of copper and zinc and sometimes a little tin. They are rigid enough to drive into ordinary deal battens without bending, and resist corrosion very well.

Slating and Tiling Battens

639. Battens or laths for supporting slates and tiles are sawn from Baltic timber (yellow deal) in 10 ft. lengths and should be straight grained and free from defects such as shakes, sap and knots; they vary from 1¼″ × ¾″ to 2″ × 1″ in section. The best tiling laths are of oak which necessitates strong nails, where such are employed. These laths may have to support the tiling or slating across the free space between rafters, in which case the larger sizes are necessary; the smaller ones are chiefly used to lay upon roof boarding.

Asbestos Tiles

A modern product, largely used in industrial and temporary structures for covering roofs, is the asbestos-cement tile. It is variously known by special or patent names applied by the manufacturers, as poilite, asbestolite, etc.

The material is a fibrous cement compound in which asbestos is employed and is prepared in thin, hard, fire-resisting slabs of various colours, chiefly grey, red and blue.

640. Plain asbestos tiles. The common tiles are about $\frac{1}{4}''$ thick and in squares of about 16″ side, having two opposite corners removed about $2\frac{3}{4}''$ each way. They are laid diagonally with the margins overlapping $2\frac{3}{4}''$ to 4″ as desired, the two cut angles meeting in the slope of the roof and the joint being covered by the succeeding course of tiles. Copper rivets are usually employed to secure the tail corner, passing through the three thicknesses which occur there. Two nails are also used for fixing each tile in the upper edges, where covered by the succeeding slabs.

These tiles are very light in weight, the finished covering averaging about $3\frac{1}{2}$ lbs. per sq. ft. Resistance to wind is very good because of the tail fixings employed.

The greatest objection to asbestos tiles is the crude colouring and lack of texture which makes artistic work almost impossible.

Other forms of covering, such as the Trafford asbestos tile, are much used for industrial buildings (see also paragraph 174 for a description and illustration of Trafford tiles).

641. Corrugated sheeting. Corrugated sheets for roof covering are made in grey and coloured asbestos-cement and used in a similar manner to corrugated iron. The sheets by Turner's Asbestos Cement Company are $\frac{1}{4}''$ thick and roughly up to 8 ft. long × 3′ 8″ wide, and have $16\frac{1}{2}$ corrugations to the sheet at $2\frac{5}{8}''$ pitch. The side lap is 4″ and end lap 6″, and the angles are mitred to these dimensions where the double lap occurs at the junction of four sheets. Each sheet covers over 24 sq. ft. of roof surface.

The sheets are usually secured to wood purlins by galvanised iron screws with limpet or asbestos washers; hook bolts may be employed for securing to steel purlins. Overlaps for exposed positions are bedded in or pointed with special composition.

IRON COVERINGS

642. Corrugated steel sheets. An old and useful method of covering temporary and emergency structures is to employ galvanised corrugated sheets of iron; these were the forerunners of the asbestos-cement corrugated sheets.

They are prepared from sheets of iron or mild steel of gauges varying from No. 24 to No. 16 Birmingham Wire Gauge.

Long life can be given to corrugated iron by special preservative coverings, which have been introduced in recent years and applied with great success to railway work and to industrial buildings of a semi-permanent character.

The covering widths vary from 2 ft. to 2′ 6″ plus a covering lap of one to one and a half corrugations and the lengths vary from 5 ft. to 12 ft. by half-foot increments. Corrugations consist of alternate rises and depressions at 3″, 4″ or 5″ centres, and run lengthwise of the sheets.

The available length depends upon the thickness or "gauge" desired. Gauge No. 16 is obtainable in lengths up to 8 ft.; No. 18 up to 10 ft. and one form of No. 24 up to 12 ft.; the average length is 6 ft. to 9 ft. For the method of fixing see paragraph 174 and detail No. 52.

643. Zinc. Sheet zinc is in considerable use for roof coverings, gutters and down pipes, because of its cheapness.

The lightest gauge allowable is No. 14 zinc gauge, but No. 16 should be employed for gutters, rolls, etc.

Zinc forms a light covering, but is not very durable, and in no way comparable with lead for flat roofing.

As the expansion and contraction due to changes in temperature are slightly greater than for lead, the sheets and component parts of the covering must be secured with freedom to expand and contract, and yet remain watertight.

Coverings to flats are made to standard sizes between rolls, with standard caps, ridge plates, clips and stops at the rolls and drips.

Corrugated zinc sheets are also made to lay directly upon rafters with rounded top edges, the junctions being made by overlaps on the same rafter.

Soakers are often made of zinc because of its thinness as compared with lead.

644. Copper. Copper is a suitable material for the covering of steep, ornamental roofs to turrets, small spires, domed structures, etc. It is expensive but durable, and is not subject to so large an expansion as lead with the same increase of temperature.

The appearance is always satisfactory, especially after exposure to the weather has produced a carbonated surface of patchy green colour.

The weights usually employed are from 24 to 21 B.W.G. (from 16 ozs. to 24 ozs. per sq. ft.).

Copper is easily shaped for tiling curved roofs, and embossed tiles are obtainable for special purposes both in copper and zinc.

Patent Coverings

645. Vulcanite roofing is one of the more modern forms of asphaltic covering. It consists of alternate layers of asphalted sheet and vulcanite composition, the latter applied in a liquid state as the sheets are asssembled. Used largely for flat roofs and protected against atmospheric changes, fire, and wear by 1½″ to 2″ of gravel

and coarse sand. There must be sufficient fall to allow of free drainage.

646. **Ruberoid** has been very successfully employed as a covering on pitched and flat roofs. It consists of a flexible sheet, impregnated with a non-bituminous compound, and is flexible, tough and leathery in appearance. Joints are made by lapping, cementing and nailing.

Other patent coverings varying in mode of preparation, character and treatment, but belonging to the class of semi-temporary coverings, are Rok-roofing, Anderson's Stoniflex Roofing Felt, Rexilite, Congo and Combinite roofing.

647. **Willesden paper.** Paper and canvas which have been treated to render them tough, and non-inflammable, are supplied under the names of Willesden paper and Willesden canvas. The paper is used as an under-covering on good roofs in the same way as asphalted felt; the canvas may be similarly employed but is also used as an external covering and needs protection by oil paint when so exposed.

Materials Used by the Plumber

648. **Lead.** This plastic metal is obtained by smelting lead ore, called *galena*, in special furnaces. The metal is heavy, its density being about 710 lbs. per cu. ft.; it is also soft and malleable and easily fused.

Lead used for roof work is milled sheet, rolled from slabs of cast lead, which, in the process, become sheets of uniform thickness having a maximum breadth of about 9 ft. and a length of 33 to 36 ft. The length varies with the weight per foot super, the total weight of a roll of sheet lead being approximately 11 cwts.

Rolling makes the soft cast lead tougher, closes flaws, consolidates it and reduces its flexibility. It still, however, retains this latter quality in a great measure making it easy to apply and adapt to the various bends and angles occurring in roof work such as gutter linings, coverings to flat roofs, cesspool linings, etc.

Lead is rolled in thicknesses corresponding to a weight of from 3 to 10 lbs. per ft. super, but nothing thinner than 5 lbs. lead should be employed for roof plumbing of a permanent nature, and it is unusual to employ lead heavier than 8 lbs. per ft. super.

649. **Weight of sheet lead for special purposes.** The following weights of sheet lead are recommended for the purposes described:

Linings to large gutters and coverings to flats ...	7 or 8 lbs.
Smaller gutters and flats, ridges, chimney backs	6 or 7 lbs.
Cover and stepped flashings, soakers, etc. ...	5 lbs.
Pipes 2″ to 3″ diameter, equivalent to ...	6 lbs.
Pipes above 3″ diameter, equivalent to ...	7 or 8 lbs.

650. Expansion of lead. Lead expands nearly three times as much as iron for the same rise in temperature, its coefficient of expansion being approximately ·000016 per degree Fahrenheit. Because of this expansion lead sheets of large size, and any pieces which are so fixed as to resist movement under the expansive force, will often buckle and bulge. For the same reason lead on vertical surfaces requires support at intervals, otherwise the weight of lead hanging on the supporting parts would be so great as to prevent the expanded lead regaining its original length and position, resulting in crinkled coverings which get thinner with each expansion and failure to return to the original position. Lead pipes require good support at frequent intervals for the same reason and especially so if hot liquid is passed through them.

651. Lead pipes. Most lead pipes are now made by the "solid drawn" process, having no seam or joint in their circumference. They are used to distribute the supply of water (and gas) within a building, to convey it from the main to the dwelling and also to carry off wastes from sanitary fittings.

Below 2″ in diameter, pipes are usually described and specified by their weight per yard run and for conveying water under pressure the following weights are required:

For	$\frac{3}{8}''$	bore,	5 lbs.	per yard	lineal
,,	$\frac{1}{2}''$	,,	6	,,	,,
,,	$\frac{3}{4}''$	,,	9	,,	,,
,,	1″	,,	12	,,	,,

Waste pipes from lavatories, sinks and baths may be:

For	$1\frac{1}{4}''$	bore	about	12 lbs.	per yard	lineal
,,	$1\frac{1}{2}''$	,,	,,	14	,,	,,
,,	2″	,,	,,	18	,,	,,

652. Plumbers' solder. Solder used for wiping joints in lead pipes is called plumbers' solder and is an alloy of 30 to 33 per cent. of tin and 70 to 67 per cent. of lead. It fuses at a lower temperature than lead, which is necessary to avoid damage to the lead pipe; with the aid of a flux the solder combines solidly to a clean lead surface, the fluxes employed being resin and spirits of salts. The flux enables the solder to adhere by slightly melting the surface of the piece or pieces to be united.

Fine solder is prepared for blowpipe use and for employment with a copper bit. It consists of equal quantities of tin and lead and is cast in thinner strips to facilitate its use.

653. Copper fixings. *Copper clout nails.* These are of hard copper with thin points and flat or "clout" heads. They may be obtained from $\frac{3}{4}''$ to $1\frac{1}{4}''$ long and are employed to secure the fixed edges of

lead sheets by close nailing—at about 1″ centres—or open nailing—at 2″ to 3″ centres.

Copper clips or tacks. The copper sheet used for tacks or clips is pure rolled copper of a soft nature.

It is employed in thicknesses of $\frac{1}{32}''$ and upwards, being cut from 22 oz. copper sheet or from heavier metal. Copper is employed because it is much more rigid than thick lead, oxidises slowly and is therefore durable.

654. Copper pipes. These are very largely used for water services and many domestic installations are carried out entirely in solid drawn and fairly hard copper pipe. Light gauge copper tube is used with gunmetal screwed unions at all lengthening joints.

The following gauges of metal are used for tubes of standard bore:

$\frac{1}{2}'' \times \frac{3}{4}''$ 18 gauge.
$1'' \times 1\frac{1}{2}''$ 17 gauge.

These tubes will resist a much greater bursting pressure than lead pipes of adequate strength and designed for the same purpose. The bore is clean and smooth and offers less obstruction to flow than lead pipe.

Copper is also used for pipes of large bore—such as wastes and soil pipes—up to 4″ diameter. The joints for all pipes above $1\frac{1}{2}''$ diameter are best welded at the joints. This branch of copper pipe fitting and jointing requires special training and careful work.

655. Cast iron waste pipes. Pipes of cast iron are used by the plumber for rain-water down pipes, soil pipes and vent pipes.

They are cast with spigot and socket joints and may have either cast-on ears for their support at each socket, or separate cast ears, or wrought "pipe bands" or holders.

Down pipes for rain-water should be not less than $\frac{3}{16}''$ in thickness. They are usually made in 2 yard lengths and in two strengths called "ordinary" and "strong", which refers to the thickness of the metal. Ordinary pipes are liable to be faulty and too thin in parts, hence the strong pipes are preferable.

When 4″ diameter or over, whether for rain-water or soil pipes, the minimum thickness should be $\frac{1}{4}''$.

Special parts are supplied such as "bends", to change the direction of the flow; "knees" and "offsets", to pass projections such as plinth courses; "swan neck" bends, for directing the water from projecting eaves to down pipes on the wall; "shoes", for discharging over gully gratings or into channels; "branch pipes", for connecting subsidiary pipes to a main pipe; "heads", open or expanded tops for receiving the discharge from several pipes.

It may be noted here, that a judicious selection of the position of

a down pipe and the use of a characteristic "head" may be made considerably to enhance a simple elevation.

656. Cast iron drain pipes. These are prepared in 9 ft. lengths, of heavier metal and with larger and stronger sockets to resist the caulking of lead in the joints. The sockets are not less than $\frac{3}{8}''$ thick and the London County Council require the following weights and strengths:

Internal diameter or bore	Thickness of metal	Weight per 9 ft. length including socket, etc.
3″	$\frac{5}{16}''$	110 lbs.
4″	$\frac{3}{8}''$	160 lbs.
5″	$\frac{3}{8}''$	190 lbs.
6″	$\frac{3}{8}''$	230 lbs.

If socketed joints be employed the annular space for the molten lead must be at least $\frac{1}{4}''$ for 3″ and 4″ pipes and $\frac{3}{8}''$ for 5″ and 6″ pipes.

Joints may be made by casting flanges on both ends of the pipes, turning these to a true face and bolting them together through the flanges; a sheet of approved *insertion* must be gripped between the flanges to render the joint watertight.

657. Ribbonite hanked lead is a preparation of pure soft lead cast quickly into fine ribbons which are woven into twisted hanks ready for caulking into socketed pipe joints without melting. A ring of ribbonite is first caulked into the bottom of the socket and the pipe set in true alignment; this is followed by a ring or rings of yarn gasket and the rest of the joint completed with caulked ribbonite.

The joints so made are said to be much stronger, more satisfactory in every way and much more convenient and economical than molten lead.

658. Cast iron eaves gutters. These are supplied in numerous designs and sizes to suit projecting eaves, ordinary or flush eaves and boundary walls where no projection can be allowed.

Most of the lighter gutters are in 6 ft. lengths plus the "faucet" end. The minimum thickness for reasonable service is $\frac{1}{4}''$, though many gutters are cast thinner than this.

Forms of eaves gutter are shown in Vol. I, and we only need to note here that in selecting a gutter attention should be paid to the position and method of securing, with a view to subsequent repairs and painting. Half-round gutters, clearly projecting from a fascia and supported by brackets which keep the gutter clear of the woodwork, are best; they can be painted all round at any time and are easily removed for repairs. Other forms, with flat bases and backs, always have some portion of the exterior hidden and inaccessible for painting. Where this occurs special and adequate preservative

treatment must be applied before erection and it is proved that coating with bituminous preparations gives the most reliable results.

659. Cast iron V and parapet gutters. These are primarily of the section shown in detail No. 53, but may have a V, bevelled trough, or irregular section, or a rounded base as required by the form and construction of the roof.[1] Many standard forms are made and it is good policy to arrange details to suit these if other work does not suffer by their use.

Most of these special gutters have to carry their own weight across a clear span between trusses, and in many cases support the feet of the common rafters; they may therefore need to be very strong, probably $\frac{1}{2}''$ to $\frac{5}{8}''$ thick.

All joints, where feasible, are made by providing external flanges, though one or more internal flanges have sometimes to be employed; these are recessed, trued up on the edge margins, bolted together, and the joint made by iron filings.

660. Rust joints to gutters and pipes. The filings are wetted and mixed with crushed salammoniac, and when partially oxidised the mixture is rammed into the joint. Expansion occurs during oxidation and a watertight joint is accomplished without damage to the flanges—assuming careful and experienced workmanship. Large cast iron pipes for hot water work are frequently jointed in the same manner, though these large pipes are not favoured for modern heating schemes.

661. Preservation of gutters, pipes and external ironwork. Where the subsequent application of paint and the production of a good surface finish will not be interfered with, the best method of preserving iron pipes, etc., is to dip the entire mass into a hot bituminous bath. The best known and most widely used preparation for this purpose is Dr Angus Smith's solution which is said to consist of pitch, coal tar, resin and mineral oil. Materials to be preserved are first cleaned—except when they are new—raised to a temperature of 600° to 650° F. and then dipped into the hot mixture which must be in a very fluid condition. The coating should set firmly on cooling.

This method of preservation is most suitable for drain pipes and hidden work, as the dripping preservative often leaves streaks and thick patches.

Several bituminous solutions, some of which are to be applied while hot, are now successfully used. A few of these may be covered with oil paint after a few months' exposure to the weather; and this

[1] See Macfarlane's catalogue of gutters, down pipes, etc.

is a great advantage as preparations which are otherwise good ooze through ordinary paints in a short time.

662. Barff's preservative process. Pipes and boilers are often "Barffed", which consists of raising the temperature of the material to a red heat and exposing to the action of superheated steam; this results in the formation of a film of magnetic oxide of iron on the surfaces, which prevents further oxidation taking place for some time.

It is by no means a permanent preservative.

Materials Used in Drainage and Sanitary Fittings

663. Earthenware. This is the term applied to the commoner articles made from brick earths such as shales and marls with little or no preparation beyond grinding and mixing, then moulding and pressing to the required form.

With good earths and suitable processes of manufacture, some very good sanitary ware is obtained in this way, but there is no certainty of the quality and unsound, weak, and porous goods are often produced; further, as much of it is glazed there is a possibility of the defects being hidden, hence careful examination and testing are necessary to detect unsoundness and porosity.

Defects which do not appear on the surface may be detected by tapping the material with a hard instrument; a clear sound should result. In the case of pipes, if dead or dull and yet no visible defects occur on the surface, test under water pressure is the only satisfactory method of determining suitability.

664. Fireclay ware is made from the refractory clays of the coal measures. These clays vary much in nature but are capable of withstanding high temperatures without fusing. The more sandy fireclays are liable to produce goods which are imperfect because of insufficient vitrification; they are then somewhat loose and friable and likely to be porous. For this reason fireclay goods should be made thicker than those of a better material such as stoneware.

665. Stoneware. The best sanitary goods and many goods for chemical purposes are made of stoneware. This term is applied to the ware manufactured from highly siliceous clays which are chiefly found in the Lias formation.

The composition of these clays varies from 70 to 75 per cent. silica with 24 to 30 per cent. alumina, and very small quantities of iron, lime, etc. These clays are sufficiently plastic to shrink considerably in burning, hence they are often mixed with sharp sand, ground flint, ground waste stoneware, and granitic matter to reduce the shrinkage.

The best stoneware is made from clays found in Dorset and Devonshire, but many good qualities are manufactured in London, the Midlands and Lancashire.

Stoneware is the hardest of all earthenwares, being necessarily burnt at a high temperature in domed kilns in order to vitrify the material. It resists water under pressure and the action of dissolved chemicals exceedingly well; it can be recognised by its density and extreme soundness.

666. Terra-cotta is also used for sanitary goods but can only be distinguished from ordinary earthenware by the finer preparation, selection and grading of the earths, and the better and more uniform quality of the finished goods. The best terra-cotta is not so good as average qualities of stoneware, but is very much finer, more dependable, denser and sounder than the ordinary classes of goods. Good terra-cotta clay has the high percentages of silica but less alumina than stoneware clays and greater percentages of fluxes.

667. Drain pipes. These are made of diameters varying from 3″ to 18″, the most common sizes being 4″, 6″, 9″ and 12″ bore.

Most pipes are made in 2 ft. lengths, plus the socket, and they vary in thickness from $\frac{1}{2}''$ to $1\frac{1}{4}''$.

Earthenware (ordinary pot pipes), fireclay, terra-cotta and stoneware are all employed for drain pipes, but the first three are seldom distinguished by specification, being classed as lower grades when compared with stoneware.

All earthenware pipes for drainage works should be salt glazed (see paragraph 672) to ensure smoothness and thus reduce friction.

Drain pipes may be tested for bursting pressure, or for resistance to load externally applied.

The latter is the more important test, as pipes near the surface of the ground are subject to load and vibration when laid beneath public roads.

Cast iron is now much used for drain pipes, but of thicker metal than the pipes used by the plumber; see paragraph 655.

668. Portland cement. For jointing drain pipes portland cement is still the chief material in regular use; see Vol. III.

It should be fresh, but cool, and should not be over plastic. In all cases it is used neat and the spigots and sockets of the pipes are either left unglazed or serrated to enable the cement to get a grip.

It is often used as a grout to fill the annular space between turned, close-fitting shoulders of bituminous material but its function here is as a safeguard and joggle to prevent withdrawal of the joint.

669. Bricks. Bricks are employed in the construction of manholes (inspection and other chambers) and for large drains or sewers. They should be of impervious material such as blue brick, plastic engineering brick, pressed fireclay of fine grain or other sound hard burnt bricks and set in cement mortar with equal quantities of cement and sand. Joints must be perfectly flushed and the minimum thickness of walls should be 9″. For brick sewers special tapered bricks are preferable.

If bricks of a doubtful quality must be employed, they should be built for manholes in separate 4½″ walls breaking joint horizontally, grouted solid between the sections with cement and backed with clay. Picked stocks are employed in this way. It is also considered necessary to render the interior with ½″ of cement mortar.

670. Concrete is employed for foundations to chambers, benching up the channels within them and for bedding and enclosing drain pipes. Its composition should be one part cement, two parts sand and five parts coarse material measured by volume. Exposed surfaces of the benching should be finished by a rendering of cement mortar.

See also Vol. III for a complete description of the preparation and placing of concrete.

671. Cast iron is used in pipes, manhole covers, access steps to manholes, traps, bends and assemblage chambers for manhole bases. It is also employed for perforated gratings to gully traps, ventilating grids and flushing tanks, and for levers and supports to cisterns, lavatories, etc. Ordinary baths are chiefly of cast iron, ¼″ thick.

672. Earthenware sanitary fittings. Sinks, lavatory basins, W.C. pedestals, and urinal stalls are variously made of ordinary earthenware, fireclay and porcelain.

The cheaper goods are made from carefully prepared good quality brick earths, tempered to a plastic condition, hand moulded in plaster moulds, dried, burnt and either salt glazed or enamelled. Enamelling is the usual finish, as it enables the base or body material to be clothed and hides imperfections of colour and quality, provided a good surface finish is obtained. The best ware of this class has the enamel applied to the raw, dried article and is thus thoroughly united in the kiln.

Enamels are usually cream or white.

Where salt glazing is employed the clay should burn to a buff, or reddish-brown tint.

Lavatories and W.C. pedestals are almost always enamelled. The better qualities of middle class goods are made from fireclays of

a fine quality, specially selected and prepared, and finished in enamel as described above.

673. Porcelain ware. The best sanitary fitments are made of white clays, viz. clays having very little iron and a fair percentage of lime. They are finely ground, mixed with waste pottery ground to a fine white powder, tempered, moulded and burnt at vitrifying temperatures. As glazing is a sanitary necessity, even the best qualities are white enamelled which ensures a high lustrous finish and pure colour owing to the white body of the material.

674. Metals used in water taps. Cocks or taps are made of brass, gun metal and white metal.

Brass is an alloy of copper and zinc in varying proportions which affect the colour of the metal. Yellow brass has approximately two parts of copper to one of zinc, while rich or red brass has about four parts of copper to one of zinc. The increase of zinc makes it whiter but of greater fusibility and less strength. It is employed chiefly in the first named form for taps, unions, brackets, etc.

Gun metal is one of the alloys collectively known as bronze, all of which contain copper and tin in proportions varying from 16 to 1, to 5 to 1. The increase of tin adds to the hardness of the metal. For taps the material may be 10 to 1 alloy for very good work, but the alloy used for this purpose often contains three metals, viz. copper, zinc and tin. The proportions are approximately 44 : 5 : 1, giving a rich brass alloyed with a little tin.

White metal is obtained by alloying nickel with brass in varying proportions according to the whiteness and hardness desired. *White brass* contains 30 parts of tin to 1 part of copper.

Many good taps of light colour are electro-plated with nickel, chromium or silver, upon brass or gun metal.

MATERIALS USED BY THE PLASTERER, AND FLOOR AND WALL TILER

675. Lime. The product after heating limestone to redness in air. This process is called *calcining*. The original composition of the limestone is $CaCO_3$ (calcium carbonate) with foreign constituents of either an inert or active nature. The active constituents are chiefly compounds of silica and alumina (clay) and convey inherent setting properties to the lime.

Pure $CaCO_3$ when heated liberates CO_2 (carbon dioxide gas), leaving CaO (calcium oxide, or quicklime).

If inert constituents, such as sand, are present, the lime is less pure and if these amount to 10 per cent. or more the resultant material is commercially called poor lime. The terms rich lime and fat lime are given to the purer forms.

676. Quicklime or caustic lime. When water is added to quicklime it absorbs it for a considerable time without showing moisture and at the same time gives out heat and vapour. This process is called *slaking* or hydration.

A lime is hydrated when it has taken up the maximum amount of water without appearing moist. Its bulk when hydrated increases to at least double that of the original quicklime. Hydraulic limes and poor limes should not be used by the plasterer for general work. Some limes contain lumps which do not slake and must be screened out. There is always a possibility that if crushed and left in the work, they may prove to be of a hydraulic character but unslaked. Subsequently the particles may slake slowly and expand, thus damaging the work after completion by raising blisters or spalling off flakes of plaster.

677. Hydrated lime. Instead of using lump lime with the consequent trouble of slaking and preparing, hydrated lime may be obtained. The advantage of this modern preparation is that the slaking is exactly completed without any excess of moisture and the lime is in a powdered condition, screened free from lumps and foreign matter, and requiring only to be mixed with sand and water to produce mortar or plaster.

It is probable that this preparation will entirely take the place of lump lime in the builders' supply if made sufficiently economical in first cost.

Note: Portland cement—used chiefly for external plastering—is referred to in paragraph 451, *and is treated in detail in, Vol.* III.

678. Sand. For plasterers' work sand should be clean and fairly sharp, but not coarse, especially for the finishing and floating coats, as it interferes with the free working of the lime plaster. For the rendering coats in some districts ground mortar is used. In this case ashes or clinker often take the place of sand entirely, but some clean medium grade of sand should be employed to avoid undue coarseness.

Provided that the clinker does not contain sulphur and soluble salts which may result in efflorescence of the plaster work, the result is a good, sound and firmly adhering coat.

679. Hair and fibrous materials. For ensuring cohesion of plaster, especially when laid on lathing, fibre of some kind is necessary as a reinforcement.

Coco-nut fibre has been employed, but is too rough and difficult to work as compared with hair.

Ox-hair is the most suitable material; it should be long, wavy, strong and free from dust and grease, and should be carefully handled

in the cleansing process to prevent cutting and bruising, otherwise the reinforcing power is greatly impaired.

Hair often requires separating by lightly beating the matted portions.

680. Plaster of Paris. This is manufactured by calcining and grinding gypsum, which is a hydrated sulphate of lime found naturally as a soft stone of varying colour. Selenites and alabasters are forms of gypsum, the former being transparent and the latter white, fine grained and opaque, and often nicely shaded and veined in very light tints.

The raw material is abundant in the neighbourhood of Paris and in the following English counties: Derbyshire, Nottingham, Cheshire and Westmorland.

To obtain the plaster the stone may be first crushed or it may be calcined in the lump. The object is gently to reduce it from the hydrated condition to a dry sulphate of lime. It is eventually ground to three qualities which are classed as "superfine", "fine" and "coarse". The better qualities are whiter than the coarse which has a reddish tinge.

Plaster of Paris is largely used for quick-setting plaster and for ornamental work. It sets very quickly, being firm in a few minutes after mixing and soon attains its full strength. During the setting process it expands appreciably and is thus suited for repairs and stopping.

This plaster is the basis of most plasterers' cements sold under proprietary names, such as Keene's, Parian, Martin's, Robinson's, Sirapite, etc.

681. Keene's cement. This is one of the plasters in very common use. It is prepared by soaking calcined gypsum in a solution of alum, drying in air and then gently recalcining to evaporate the moisture; the colour of Keene's cement is a very light tint of reddish cream, which is conveyed by the addition of a small quantity of copperas to the alum solution.

The cement is prepared in coarse and superfine qualities. It sets quickly, though slower than plaster of Paris, and becomes quite hard and dry in three days. It works freely, and in the fine qualities works up to a hard and lustrous surface. The cement is used for angles, architraves, skirtings, columns, pilasters and cornices.

It is invaluable for surface work which is to be papered or painted within a short time after completion.

Where the plaster is to be applied over brickwork or rubble walls the face should be first rendered in portland cement and surfaced with Keene's.

While the cement may be used as a gauging for lime plaster[1] it is best employed neat.

682. Parian cement is a whiter preparation made from calcined gypsum by saturating the roughly ground material with a strong solution of borax, after which it is dried, re-heated, ground, and, in some cases, mixed with alum. It is supplied in the same qualities as Keene's cement—coarse and superfine.

This cement is more popular than Keene's for large surfaces as it works very freely. Owing to its composition it will not effloresce under any normal circumstances.

The cement is not so fat as most other cements, which is a slight defect for the running of moulds and cornices where sharp arrises to fillets are desirable. In flat surfaces it has, however, the quality of translucence and lustre which makes it admirable for high finishes.

683. Martin's cement has many of the qualities of Keene's and Parian cement and is more economical than either, as it covers more surface for the same original quantity of plaster.

It is prepared from calcined gypsum by saturating in a solution of potassium carbonate, with the addition of diluted hydrochloric acid. Three qualities are marketed, comparing exactly with plaster of Paris. The coarser qualities have a reddish tinge, but the superfine is a pure white and gives an excellent finish.

684. Sirapite is another gypsum plaster prepared by soaking it with petroleum after calcination, then grinding to a fine powder. Its sets rapidly when made into a paste, but not so speedily as pure plaster of Paris, dries rapidly and much harder than lime plaster, yet is tough and not easily cracked or ruptured; two-coat work is the rule except on metal lathing.

The material is manufactured by the Gypsum Mines, Ltd., in Sussex and Derbyshire and has become well known and appreciated in general plasterers' work.

In the hands of a competent plasterer, sirapite can be expected to give excellent results, but it is necessary to work quickly and accurately owing to the rate of setting, and decorative work in mouldings, etc., cannot easily be done with it for the same reason.

The plaster finishes to a highly polished surface, where desired, adheres well to hard burnt bricks except when these are highly glazed, will key satisfactorily to lath work of sawn timber or to expanded metal, and tends to preserve the latter where used.

It is not successful if applied to permanently damp walls; if too highly polished in finishing it is liable to condensation.

[1] See paragraph 443.

The first coat should be of one part sirapite to three of clean sand, if applied to walls, but equal parts of sirapite and sand upon wood lath work; putty-lime is often mixed with the first coat in small quantities, and for lath work (especially metal) equal parts of sirapite and ordinary hair-plaster may be substituted for the above. Finishing coats should generally be of neat sirapite and the total thickness of plaster should not usually exceed $\frac{3}{8}''$.

685. Selenitic cement is another example of the use of calcined gypsum. The latter is added to a feebly hydraulic lime in quantities varying from 4 per cent. upwards, by mechanically mixing and grinding with the lime. When water is added to the mixture it does not slake, the sulphate of lime having acted upon the quicklime in the mixture and suppressed the slaking action. The sulphate of lime causes quicker setting, and produces greater strength and adhesion. The cement will adhere well to brickwork in the rendering coat and may be used without hair, thus encouraging two-coat work.

Selenitic plaster, properly prepared, will produce a surface equal to the patent cements. It is non-absorbent and easily washed, but liable to condensation.

686. Wood laths. Wood laths may be of sawn yellow deal (Baltic fir) or of oak, but the best laths are cleft from the material to preserve unbroken grain, which largely increases their strength.

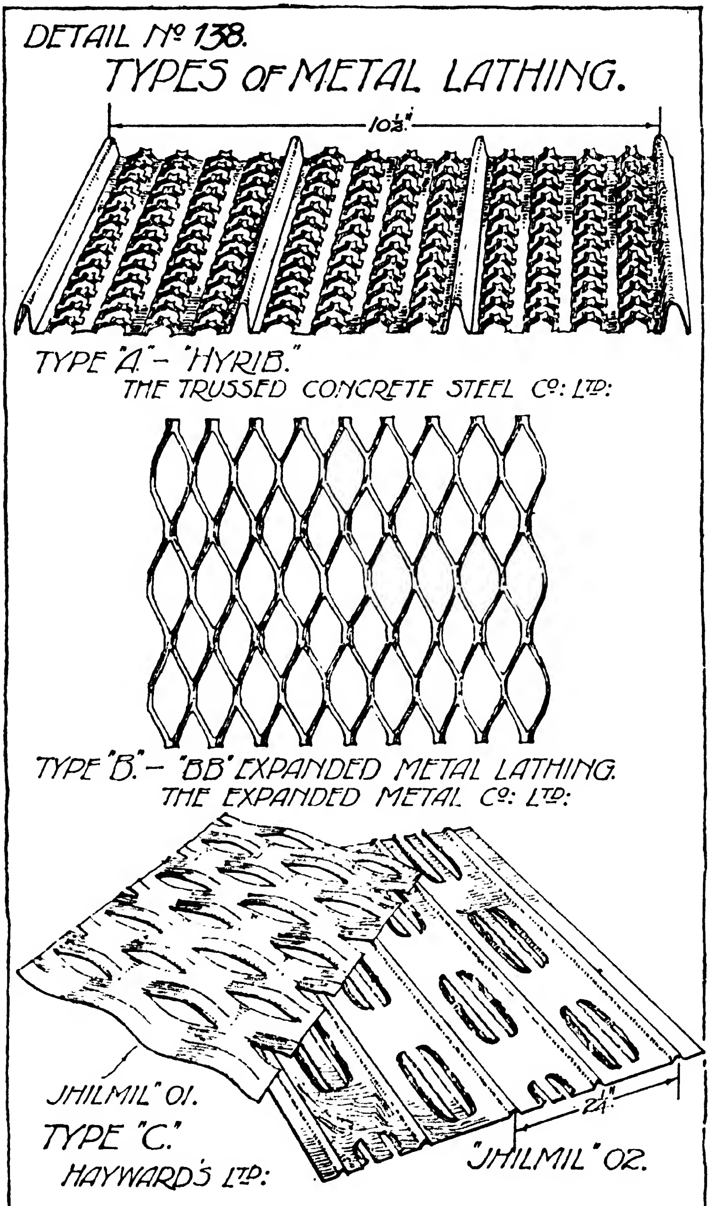
These two kinds are known respectively as *sawn* and *riben* laths; they should be free from sap, knots, wavy and diagonal grain and be reasonably straight in length.

Laths are usually 3 ft. to $4\frac{1}{2}$ ft. in length, $\frac{7}{8}''$ wide and $\frac{3}{16}''$, $\frac{1}{4}''$ to $\frac{5}{16}''$, or $\frac{3}{8}''$ thick; according to their thickness they are named "single", "lath and half", and "double" laths, in the order of thicknesses given. "Single" laths should not be employed, being too weak for reliable work; "lath and a half" laths are suitable for ordinary work, if the supporting members have a clear spacing not exceeding 12".

687. Metal lathing. Cut and deformed sheets of metal are much used for lathing and three types are shown in detail No. 138. Type A is known as Hy-rib and is used as a basis for partitions and ceilings; it is bent at intervals to form a stiff rib projecting from the plane of the sheet and requires little intermediate support as compared with plain sheets.

Type B is an example of cut and expanded metal of small mesh and of light weight and is known as "B.B. Expanded Metal Lathing". It may be fixed to wood or to steel members by staples or by wire clips.

Type C is also a cut and deformed sheet known as "Jhilmil", and two patterns are shown; the 02 pattern is a stock form, and 01 may be obtained to order. The former is an improved form prepared by Messrs Haywards, Ltd.


DETAIL Nº 138.
TYPES OF METAL LATHING.
10½"
TYPE "A" - "HYRIB."
THE TRUSSED CONCRETE STEEL Cº: LTD:
TYPE "B." - "BB" EXPANDED METAL LATHING.
THE EXPANDED METAL Cº: LTD:
"JHILMIL" 01.
TYPE "C."
HAYWARD'S LTD:
2¼"
"JHILMIL" 02.

Metal lathing should be well protected by special paint or galvanising, as if rusting takes place the pattern of the mesh soon shows through coatings of white plaster of the average thickness.

688. Floor tiles. Floor tiles for internal work are generally slabs of fine earthenware varying in size from 3″ to 6″ square and ½″ to 1″ thick. They are also obtainable in rectangular pieces of various sizes for borders and in triangular and other forms for fillings to diagonal and polygonal patterned work.

There are two classes of tiles: common and encaustic.

Common tiles are made from ordinary earths of good quality and are now largely made by the semi-dry process, the shale being ground, moistened, pugged and die-moulded under great pressure. If made from strong clays they tend to warp in drying and must be corrected by "thwacking" with a wooden beater.

These tiles should be burnt at a high temperature in domed kilns to obtain sound vitrified ware, otherwise they are friable at the edges and are no use for paving.

Common red tiles, from $3'' \times 3'' \times \frac{1}{2}''$ to $12'' \times 12'' \times 1\frac{1}{4}''$, are ordinarily referred to as Quarry Tiles, or Quarries.

Encaustic tiles have their colouring throughout the mass of the tile, being tinted by substances mixed with the clay. Some tiles have surface patterns printed or transferred to their faces and others are surface enamelled or "slipped" to obtain their colouring; these are not encaustic tiles though sometimes sold under that name.

Unglazed encaustic tiles are suitable for floor finishes and are often laid in multi-coloured patterns embedded in tinted Keene's or portland cement according to their colour.

689. Wall tiles. Encaustic tiles are often glazed for use as wall tiles, but a more satisfactory type of modern decoration is to impress suitable patterns in relief upon the faces of the tiles, then coat with a slip which flows into the hollows more thickly and only tints the higher parts lightly. The variable toning of these tiles is often very satisfactory.

Panelled patterns are also prepared in embossed outlines, the pattern often being spread over several tiles, which are separated for burning, then reassembled on a plaster backing to form the complete unit.

Flat printed patterns and variable colouring in hand tints are also obtainable, the colours coming from the kiln with remarkable purity under the highly glazed finish.

The best wall tiles are keyed behind to give adhesion to the bedding plaster and the tiles should be well wetted before bedding.

690. Dry tiles. Many tiles, and especially those of small dimensions, are made by the dry process. If required to be coloured the clay or earth is prepared, "slipped" with the colouring matter, dried and reduced to fine powder.

The tiles are then dry pressed by a steel die and issue as dry but well consolidated blocks which may be gently handled without damage. They are then baked at high temperatures in continuous kilns. Excellent tiles of this character are made at Poole in Dorsetshire.

691. Marble tiles are obtained by sawing blocks of marble of various colours into thin slabs and shaping these into squares or polygons as required. Combinations of colour are particularly important in selecting the marbles to be employed and information should be obtained as to the abrasive properties in addition to the colours, so that the wear may be uniform.

Plain square tiles of white marble, laid diagonally with the joints wide enough to be emphasised, are very pleasing. They may need a border of tinted marble in geometrical patterns to harmonise with the surroundings in halls and corridors.

692. Italian or Roman mosaic is laid on a bed of concrete and is chiefly done in modern work by regular and very small tiles $\frac{3}{4}''$ to $1''$ square. They are usually reversely attached to paper or flexible material on which the design is worked, and may then be bedded down in one mass while held together in this way as previously described in paragraph 458. The tiles are of the encaustic type made by the dry process.

693. Venetian mosaic or Terrazzo is a floor surface compounded from portland cement, sand and selected stone, tile or marble chippings, laid *in situ*, and finished with a polished surface. Its application and method of laying in plain or ornamental patterns is described in paragraph 457.

Materials Used by the Glazier and Painter

Glass

694. Glass is a more or less transparent material, of a non-crystalline character, hard and brittle under normal conditions and at usual temperatures.

The material is of an amorphous character passing continuously from the liquid to the solid state without evolution of heat or retardation of cooling. It may be regarded as a congealed liquid, being a mutual solution of a number of chemical substances. The essential constituents are silicate of calcium or lead combined with the silicate of an alkali.

Fusion of these materials produces a transparent substance, practically resisting the soluble action of water, plastic and workable at an ordinary red heat.

In English glass silicate of calcium is the usual base and the alkali provided by salt cake (sulphate of soda), the resulting material being a silicate of calcium and soda. To clarify and whiten the glass a small percentage of white arsenic (As_2O_3) is introduced during the manufacture.

The glass most usually employed for architectural purposes is manufactured either by rolling or blowing.

Plate or Rolled Glass.

695. Rolled glass. Hot viscous glass is readily rolled and pressed into sheets by special machinery. The process consists of rolling the plastic mass into rough sheets of varying thickness by heavy iron rollers over a flat metal table.

If the glass be of selected quality and a suitable mixture, it can, by subsequent processes, be converted into polished plate.

696. Rough plate or rough rolled plate. This name is given to a medium quality of glass produced by the rolling process and having a dull and irregular surface due to the buckling of the viscous mass in flowing under the pressure and also the minute irregularities of the roller or table. It is used in this form for glazing skylights, lower parts of factory windows, railway station roofs, etc., being dimmed and translucent by the nature of its surface. Often called rough cast plate and obtainable from $\frac{3}{16}''$ to $\frac{3}{8}''$ thick.

697. Polished plate. If the glass is produced of a high quality with a view to polishing, it may be converted into polished plate by first annealing in kilns where the temperature can be regulated as the sheets pass through; then cutting off the rough edges of the sheet and finally polishing both faces. Polishing is done on rotating horizontal tables of large diameter, with rotary rubbers, the rough faces being reduced by grinding with grit and water. The abrasive is gradually reduced from a coarse to fine grading and finally polished by felt pads with rouge and water. The polishing action is partly chemical and partly mechanical, the surface of the glass becoming heated and the minutely pitted face dragged or smeared over until the irregularities are smoothed away.

The resulting glass is called *British* polished plate and is obtainable from $\frac{3}{16}''$ to $1\frac{1}{2}''$ thick in large sheets.

698. Special rolled plate. Much rolled plate is made with special flutings, surface patterns, or prismatic formation during the rolling process. These forms hide the defects of rough plate and increase their efficiency in many cases without the expense of polishing.

The following kinds are obtainable:

Plain rolled (with fine fluting), $\frac{1}{8}''$ to $\frac{1}{4}''$ thick.

Fluted rolled (with medium fluting), $\frac{1}{8}''$ to $\frac{1}{4}''$ thick.

Corrugated rolled (having broad waves), $\frac{1}{4}''$ thick.

Prismatic rolled (saw tooth section), $\frac{3}{16}''$ thick.

Rough chequered, Diamond, Cathedral, Muranese, Arctic white, Figured rolled, Wavene (tinted and fine mottled), Morocco Stippled rolled, Muffled (white and tinted) and other specialities by various firms.

Glass of various thick grades and either rough or polished finish can now be obtained which is reinforced with wire mesh, either the ordinary fine hexagonal mesh—known as chicken wire—or square mesh. The latter is known as Georgian wire reinforcement. The wire mesh is completed enclosed in the glass and prevents shattering and flying when exposed to great heat or when accidentally hit.

Students should carefully examine samples of the large range of glazing material produced by such firms as Pilkington and Chance, and note the effects which can be obtained by assembling different kinds of glazing for association in leaded lights and ornamental glazing.

Sheet Glass

699. Sheet glass. This material is used for most ordinary glazing and is prepared by blowing and swinging a mass of pure white molten glass into a cylindrical form. The lower end is caused to collapse and straighten, the upper end cut off, the cylinder split, opened out later at a dull red heat, flattened and annealed in a special kiln. Sheets of glass so prepared are sorted and cut to market sizes.

The defects of this glass are numerous. Infusible impurities cause "stones"; low temperature and faulty composition cause "white crystalline patches"; enclosed air bubbles become elongated in blowing and cause "blisters"; other defects are "seed" caused by dust coming into contact with glass or by incomplete fining of glass in the furnace; "string", due to lack of homogeneity of the material, forming thickened ridges or striae, and "waviness" caused by irregular formation of the cylinder in expanding it.

Sheet glass is described by its grading or quality and the weight in ounces per ft. sup.

700. Crown glass is now almost obsolete for the purpose of window glazing. Flat circular discs were produced by blowing and twirling a mass of hot glass, first into a spherical hollow ball, then opening and rotating in front of a special furnace, until the disc was formed by centrifugal force.

Where attached to the blowing tube, a bullion, boss, or bull's-eye is formed, thick at the centre and diminishing outwards.

These are sometimes used for glazing, where "antique" effects are required.

The process described is still employed for special productions, but not for obtaining large sheets of glass.

701. Patent, or blown, plate glass. A special variety of polished glass is produced in the same way as sheet glass by blowing thick cylinders of very pure glass, opening and annealing and then grinding and polishing in the manner described for polished plate. The sizes of the sheets obtainable are necessarily limited, hence large panes must be of polished plate made by the rolling process.

702. Tinted glass. All glass can be tinted to any desired colour and shade either by fusible colours introduced into the mass of material or by "flashing", that is, covering with a thin layer of tinted glass. The production and employment of tinted and stained glass is out of the range of this volume.

Paint

In the preparation of paint, some or all of the following classes of material are employed: base, vehicle, solvent, drier and colouring pigment; see Chapter Twenty-one for a description of their functions.

Bases

703. White lead is one of the principal bases or body colours employed, and consists of a basic carbonate of lead ($2PbCO_3$, PbH_2O_2).

It is usually prepared either by the stack method, or by some precipitation process. In the former process rolled strips of lead are decomposed by exposure to dilute acetic acid in small pots, bedded upon layers of spent tan. The tan ferments, large quantities of carbonic acid gas are produced, decomposing the metal, and encrusting with flakes of white lead, which are removed and ground.

By the latter process a current of carbonic acid gas is passed through a solution of a basic salt of lead, when a white precipitate—carbonate of lead—is formed.

Dry methods of production, based on similar principles, are also in use.

The lead carbonate is finely ground, usually in about 8 per cent. of linseed oil. All such preparations are poisonous and require care in commercial use.

On exposure to the atmosphere pure white lead loses its whiteness and becomes grey. It is slowly discoloured when subjected to sulphur fumes and town atmospheres.

704. Red lead. If lead be heated to fusion, it absorbs oxygen and is converted to a dull grey powder or dross (PbO). When raised to a high temperature the monoxide, under special conditions, is converted into "red lead" or "minium", Pb_3O_4.

It forms the basis of many paints for the preservation of iron and steelwork and is also employed with white lead as a base for paints to be applied to wood surfaces.

About 9 per cent. of linseed oil is required for grinding to a strong paste.

705. Zinc white (ZnO). Prepared from metallic zinc by combustion or by action of heat on zinc compounds.

Zinc is volatile and readily converted into vapour at white heat and into zinc oxide if a stream of air is passed over it, causing combustion and producing the oxide known as zinc white. Foreign constituents can be expelled from zinc compounds by heating, leaving a residue of zinc oxide.

Zinc white is not so dense as white lead and does not give the same quality of protecting body, but is very opaque and covers well owing to its fineness, though not satisfactory as a first coat on wood and stone. It is not poisonous and there is no objection to its general use; it retains its colour in town atmospheres better than white lead, and is specially recommended for under-coats where a white enamel finish is required. About 22 per cent. of oil is required to grind it to a stiff paste.

706. Sulphide or zinc white (ZnS). A base consisting of sulphur and zinc in the proportions of 1 to 2. Not so good a colour as zinc oxide and does not spread so well, but has greater body and protective capacity.

707. Oxide of iron. A base frequently employed for cheap paints prepared ready for use, or ground in oil. Obtained from the iron ore known as brown haematite and containing about 60 per cent. of iron. The ore is subjected to prolonged heat (roasted), broken and ground to powder in edge runner and roller mills.

Forms a strong colouring pigment as well as a base, and much used for preserving iron and steelwork, though not so good as red lead for the priming coat.

This base is recommended for ironwork by some authorities, in order to avoid electrolytic action, which induces rapid corrosion under some conditions where lead paints are employed.

708. Inert bases or fillers. There are many other materials which can be used as bases or fillers for giving body to paints. Those usable as white pigments are: barium carbonate, barium sulphate (barytes), calcium carbonate (whiting), calcium sulphate (gypsum),

magnesium carbonate (magnesite), silicate of magnesia (French chalk), hydrated silicate of alumina (china clay).

Their efficiency depends upon association with a good vehicle and tough driers.

Silica paint has been employed in America with great success, after severe testing for durability in impure atmospheres.

Some of the inert materials employed have been used more as adulterants, being cheaper than the more important bases first described; but it does not follow that they reduce the quality of the paint as a protective covering, except perhaps in fineness and lack of finish. For external work on metal, stone and rough timber they appear to serve their purpose very well.

Vehicles—Vegetable Oils

709. Linseed oil. The commonest and most reliable vehicle is linseed oil. It is obtained by crushing, grinding, heating and pressing linseed and thus extracting the natural oil, which is bulked and allowed to stand. When the sediment has settled the oil is refined and freed from impurities and the clear transparent oil is marked as "raw oil"; it is chiefly used for internal work and where slow drying is no objection.

For quick drying purposes the oil is prepared by heating it in association with driers such as litharge and red lead which enable the oil to take up oxygen from the atmosphere more readily.

Boiled oil is recognisable by its darker colour, due to chemical changes as certain constituents are decomposed and expelled. It is suitable for external work and positions where expansion and contraction are considerable, owing to its toughness when dry.

710. Poppy oil. A delicate transparent oil obtained from poppy seed in a similar manner to linseed.

Does not dry so well and not very durable nor tenacious. Suitable for delicate colours, owing to its transparency, and employed in internal decorative work.

711. China wood oil or Tung oil is obtained by cold pressure from the seeds of the Tung tree, which yield 35 per cent. of their weight in oil. Good quality oil is of pale amber colour, and somewhat dull in appearance.

It is quicker in drying than linseed oil, taking about two days to dry as against three for linseed oil.

Its chief fault lies in the nature of the dry film, which is dull and rather opaque, with a crinkled appearance.

It has not much solvent property for the driers usually introduced, and slowly thickens on exposure to light. It has, however, proved of great value in the preparation of modern enamels.

712. Other drying oils. Several usable oils are obtainable from seeds and nuts, *e.g.* hemp seed, rape seed, Scotch fir seed, tobacco seed, walnut, etc. Many of these are good driers but expensive, others have objectionable odours and are inferior to linseed in drying properties. Fish oils have been employed—some dry fairly well, but the odour is usually objectionable.

Solvents

713. Turps. The only solvent in very general use for good work is "oil of turpentine" ($C_{10}H_{16}$), commonly called "turps".

Substitutes prepared from mineral oils—chiefly petroleum—have been employed, but are not so successful.

Turps evaporates quickly and also absorbs some oxygen from the air, thus forming a hard skin with no glaze. For this reason it is employed for flatting or glazeless paint.

Turps is a volatile oil, making paint work freely, and hastening the drying process; it is the best medium for thinning paint, japan and varnishes.

Crude turpentine is obtained by tapping certain species of pines and other coniferous trees. When combined with white resin, and distilled with water, oil of turpentine is obtained, resin remaining.

If treated with vitriol it is converted into a liquid of a different character, but having the same specific gravity, boiling point and atomic weight. This substance is called "terebene" and is a powerful drier.

714. Turps substitutes. Resin spirit, shale naphtha, petroleum spirit, and coal tar naphtha are typical substitutes for turps. The first named is the best and the last named not much used for paint but employed for cheap varnishes of a quick drying character.

Driers

715. Materials used for accelerating the oxidation of drying oils used as vehicles, and known as driers, are: "patent driers", "turps", "terebene", "litharge", "red lead", "zinc sulphate", "oxide of iron" and "lead acetate", amongst others.

The selection depends upon cost and the tint of the final coats of paint. Patent driers and acetate of lead serve for light tints and terebene for the darker colours.

Red lead, zinc sulphate and oxide of iron also form basic pigments and require no assistance to obtain a good drying paint, especially where turps is also employed as a solvent.

Paints should not be made to dry too quickly as considerable contraction takes place during the subsequent hardening and cracked surfaces are liable to result.

Patent driers are often mixtures of many of the above, barium sulphate, chalk and sulphate of lime being also much used in the composition.

Litharge is the oxide of lead (PbO) formed in the first heating of lead to melting point and identical in composition with dross. The temperature must be sufficient to melt the oxide as it is formed.

Lead acetate ($Pb2C_2H_3O_2$) is a white crystalline solid made by dissolving lead or litharge in acetic acid. It is inferior to litharge, but much used in patent driers because of its light colour.

Knotting is a preparation of shellac dissolved in spirits. It is painted over knots in soft woods to prevent the excess resinous matter exuding through the paint and discolouring it. Commonly called "patent knotting".

Colouring Pigments

716. These are finely ground substances of vegetable, organic or mineral origin, used to produce variable tints in conjunction with good bases and to increase the opacity and covering power of paints. They are obtainable in powder form or ground in oil ready for speedy mixing.

The colours are very numerous and cannot be detailed here. Care should be taken in their selection and use to avoid chemical action destructive of their colour or of the durability of the paint with which they are employed. Most of them are inert substances and those of mineral origin are the most permanent colours.

Varnishes and Enamels

717. Varnish is a transparent and usually a highly glazed covering employed as a preservative for constructional material and

(*a*) to enhance the finished paint work by a brilliant and durable coating;

(*b*) to protect a natural and decorative wood grain;

(*c*) to give a finish to artificial graining or staining of common material;

(*d*) for sanitary purposes, *e.g.* wallpaper coverings.

718. Varnishes are prepared by dissolving some kind of gum or resin in oil, turps, or spirits.

Oil and spirit varnishes and enamels are made to suit many classes of work.

The quality of a varnish depends upon the nature of the resinous base and the drying quality of the oil or other solvent used. Most varnishes of good quality are made from hard gum-resins dissolved and incorporated at high temperatures with refined linseed oil and thinned to a workable consistency with rectified spirits of turpentine

Driers are added during manufacture. Good varnishes require time to mature after preparation.

Resinous gums dissolved in spirit are frequently applied with the brush as a quick drying filling coat for work to be finished in oil varnish.

The best known varnishes are: white oil varnish, white marble varnish, coach-body varnish, French oil varnish, maple varnish, pale copal and copal oak varnishes, the latter being specially prepared for inside or outside use.

Varnishes can be flatted by rubbing down with pumice powder and water when thoroughly hard; or a special flatting varnish may be employed.

Plain and coloured spirit varnishes are also largely manufactured.

719. Enamels. These are special preparations of high quality paint and varnish combined in the process of manufacture. White enamel is a favourite medium for treating both internal and external woodwork in modern buildings and the purity of tint and brilliance of finish is only obtainable by the combination of the qualities of an opaque paint with a high glaze peculiar to varnish.

Enamels can be had in almost any tint and special enamels for baths, or other fittings where expansion and contraction must be provided for, are manufactured to avoid cracking during the changes of temperature.

Well known brands of enamel paint are Ripolin, Endelline, etc.

720. Gloss paint. Paint having a proportion of varnish incorporated in the manufacture, giving a glossy varnished effect to the paint. Economical and useful in public institutions, schools, hospitals, etc.

French Polish

721. French polish is a glazing medium and protection is obtained by dissolving a resinous gum named shellac in methylated spirits and applying it with a pad, as described in paragraph 513.

The polish is similar in character to spirit varnish, but prepared with greater care to give a good body. It is usually prepared of either white or yellow colour and selected for use according to the nature of the wood to be treated. Woods of a rather neutral tint are improved by the yellow polish which adds warmth to the natural tint.

To obtain a good finish the material must be highly finished and the pores of the wood filled (or "stopped") in the early stages of the work. Special fillers are used for the purpose, made into a paste with gold size and turps.

Methylated spirit, used in the preparation of polish and brush varnishes, consists of about 90 per cent. of rectified spirit of wine and 10 per cent. of wood spirit.

The spirit of wine usually consists of a mixture of two groups of alcohol, obtained as a product of the fermentation of sugar. The spirit is distilled from the water in which the process is conducted.

Wood-spirit or wood-naphtha is obtained by complex processes in the dry distillation of wood.

The methylated spirit of commerce often contains small quantities of petroleum, and "finish" or "methylated finish" contains a quantity of resin.

Polish and varnish are made by dissolving shellac, sandarac, resin, mastic and other resinous bases in the spirit, which is extremely volatile and allows of rapid drying. Spirit is also used in the preparation of enamel paints.

Whiting and Distemper

722. Whiting is a preparation of powdered pure white chalk. It was much used for coating and renewing white ceilings and walls, but has been largely displaced by water paints.

723. Distemper. Ordinary distemper is merely whiting coloured with pigments and often in crude colours. Patent distempers have almost replaced these preparations. Whiting and distemper should be bound by mixing with fresh size.

Water Paints and Patent Distempers

724. Most of these materials are patent preparations, placed on the market ready for mixing; in some cases water is employed to mix the prepared powder or paste, while in others some special indurating solution is employed and the compound thinned with water.

The advantage of most of these preparations is that they are in some degree washable and can be renovated by sponging over; few of them will allow of thorough cleansing however, but their use tends to cleanliness and good sanitary conditions.

The best known are Walpamur, Hall's Washable Distemper and Duresco, but there are many others of good reputation.

The variety of artistic tints obtainable makes these distempers valuable as a decorative medium for plaster work, and they are largely employed in modern house decoration.

Putty and Stopping

725. Glaziers' putty. Made from fine whiting and linseed oil. For speedy drying a litle turps may be added. Used by the painter for filling or "stopping" nail holes and small defects.

726. Hard stopping. A hard stopping may be made by mixing equal parts of putty, white lead and paste filler and reducing to the required consistency by oil or turps.

Size and Gold Leaf

727. Size. A preparation of animal glues, ground to powder in order to dissolve quickly. Prepared by solution with hot water to a weak jelly. Used as a binder to inert materials and as a groundwork to prevent absorption of pastes or paint.

728. Gold leaf. Extremely thin leaves of gold, beaten out and cut into leaves $3\frac{1}{4}''$ square. Surfaces and ornaments are covered by preparing the material to a smooth finish, coating with gold size, and applying the leaf with a special brush. May be finished, when dry, to a burnished surface by friction with an agate tool.

Gold is also prepared in ribbons wound on cylinders by the American producers, the ribbons varying in width to suit many purposes.

729. Gold size. Several hard drying varnishes are specially prepared for this work. "Japanners' gold size" is quick drying and used for work to be rapidly completed. "Old oil gold size" dries slowly. "Isinglass size" is used for gilding on glass, the leaf applied while flowing wet and bound afterwards by a coating of japan.

Where burnishing is required "burnish size" is advisably employed.

Special Paints

730. Aluminium paint. Prepared by binding pure aluminium in suitable varnish and employed chiefly on ironwork.

It is bright and attractive in appearance, is a good preservative and suited for metal fittings in laboratories, hot water radiators and exposed metal work generally.

The paint is economical because of its durability.

731. Fire-resisting paint. Such paint is often prepared with a considerable admixture of ground asbestos, which reduces and retards combustion, and is employed for the preservation of wooden buildings, important wooden structural parts, and for the decoration of fire-resisting structures.

Carborundum forms a good base for a fire-resisting paint where very dark colour is permissible.

Tungstate of sodium in adequate coatings efficiently retards the progress of combustion. Fire has been resisted for considerable periods, under test, by this preparation.

***Note:** Materials used by the Concretor, the Ironfounder and the Structural Engineer are given in Vol. III.*

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